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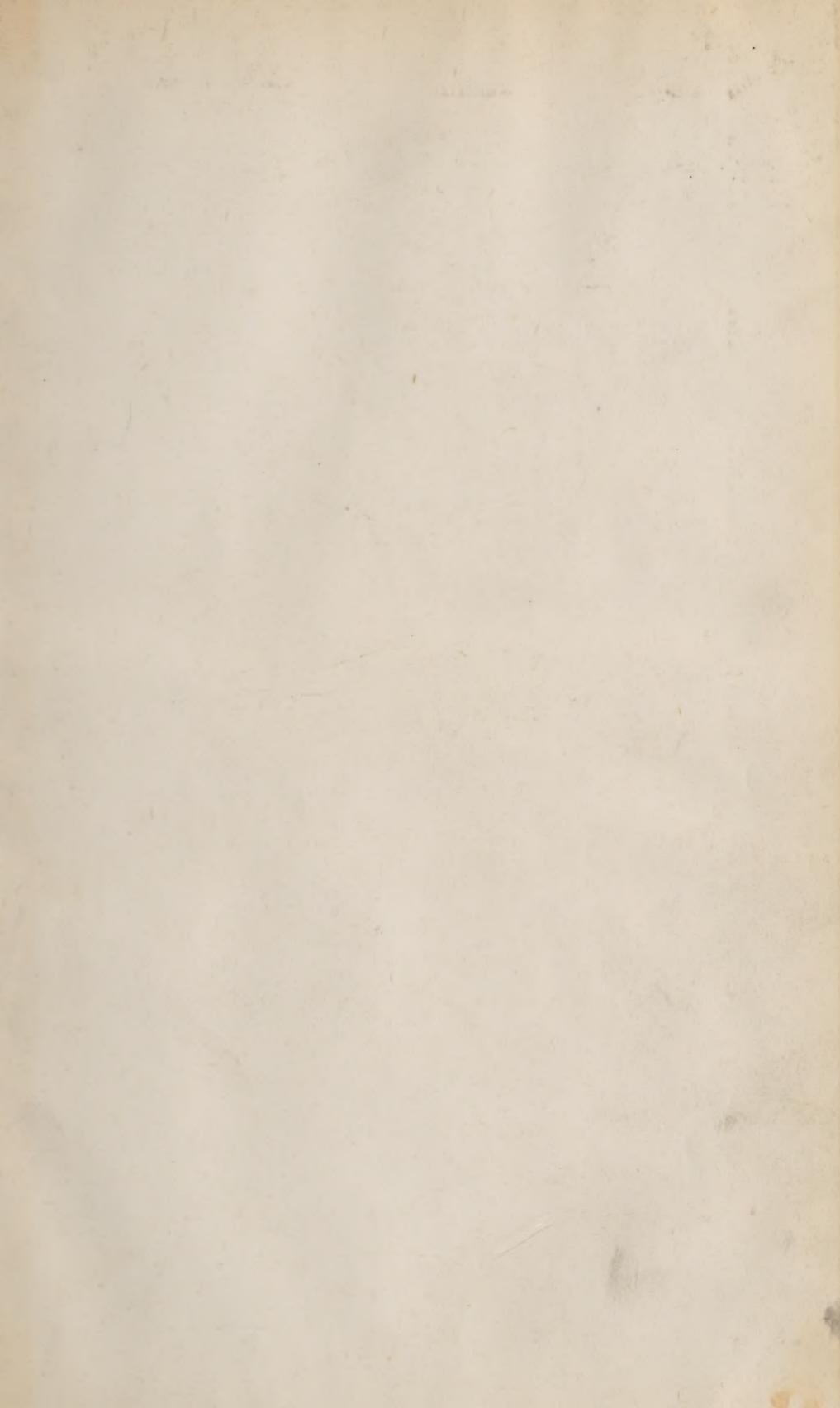
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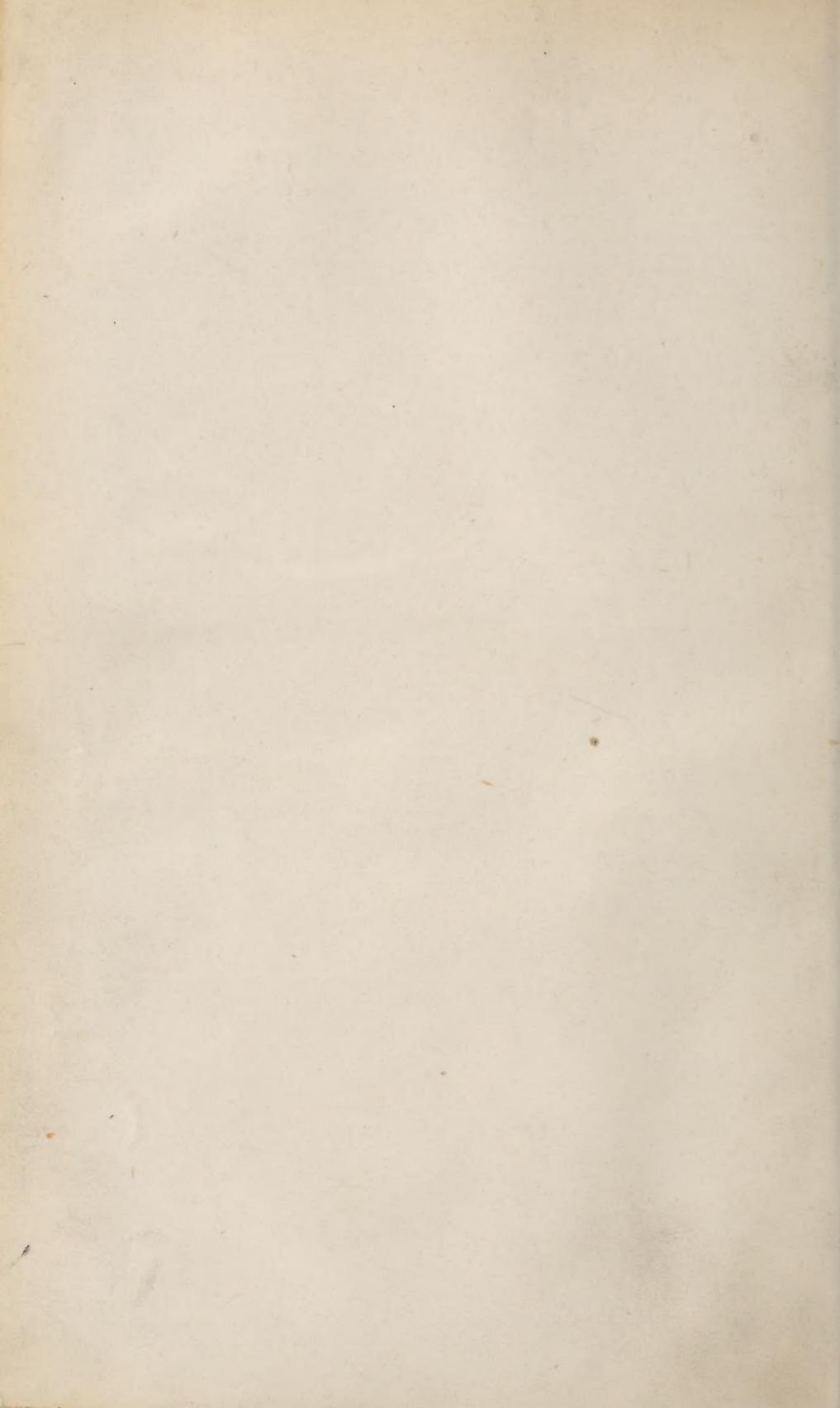












# Lectures on Military Dentistry

Collected Lectures on  
Military Dentistry from the Army  
Medical and Dental Schools

*Revised Edition*

[1941]

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## Foreword

MANY of the grave and serious problems confronting the military dental surgeon present entirely new aspects in dental surgery. These problems bring the dental officer into a closer relation with military surgery and demand a thorough knowledge of the difficulties presented, the best method for their care, and a keen understanding of the latest developments related to traumatic surgery, as well as shock and chemotherapy. Instruction of dental officers in the United States Army during the period of expansion is directed into these avenues.

The following lectures were prepared as a part of the activities of the Army Dental School, Colonel Lowell B. Wright, D.C., Director, with the collaboration of Brigadier General Leigh C. Fairbank, Medical Department (D.C.), Colonel Robert H. Ivy, M.C.R., Lieut. Colonel Roy A. Stout, D.C., and Major Roger G. Miller, D.C. Special lectures have been included. Captain Francis P. Kintz, M.C., provided the lecture on gunshot wounds of the face; Captain Douglas B. Kendrick, Jr., M.C., submitted the lecture on gunshot casualties and shock; the lectures on tracheotomy, trismus, and dietary management were prepared as monographs at the Army Dental School by Captains William P. Barnes, Jr., D.C., James S. Pegg, D.C., and Lieutenant Richard D. Darby, D.C.

In an effort to assist in the instruction of the dental profession, the lectures were delivered before the study club of the District of Columbia Dental Society.

The collaboration of both the authors and the American Dental Association in the publication of these lectures is gratefully acknowledged.

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JAMES C. MAGEE,  
Major General, U. S. Army,  
The Surgeon General.



## LECTURE I

### GUNSHOT WOUNDS OF THE JAWS

**I**N order that we may more clearly visualize the important responsibilities of the dental service in time of war, there must be a rather complete presentation of the duties assigned dental officers in combat. These responsibilities extend far beyond the bounds of the usual experience of the practicing dentist. They require deep understanding and skillful effort. While in the general field of traumatic surgery, there are so many unusual conditions surrounding these particular problems that they constitute a special field and require broad training in order to assure an efficient medical organization.

These particular problems confront the dental service in time of war and are concerned with the care of gunshot wounds of the jaws. So many factors involve our consideration of these problems that they must be properly presented to you in their regular sequence so that you may visualize the initial problems and grasp an accurate understanding of the phases which follow.

It is quite generally understood that dental officers are a part of the medical team serving with the combat troops and in every hospital and medical unit in the Army. During combat our dental officers function as auxiliary medical officers, and as such they assist in the care of battle casualties and are charged with particular responsibilities in the care of jaw casualties. Because of these responsibilities and the unusual character of this service, this course of lectures and the special training provided in the Army become a new and particular consideration for those dentists who may be called for military service.

Before discussing the duties of dental officers in the care of jaw casualties, it might be well to give some thought to battle wounds and thus bring to your attention the peculiarities of such injuries. The civilian surgeon and the civilian dental surgeon are rarely familiar with gunshot wounds. The amazing velocity of high-calibre bullets, the rotatory motion of the missile, the jacket covering of the modern small arms bullet, and the shape and weight of the projectiles are responsible for the types of wounds they produce.

The environment of the wounded soldier in battle greatly influences his treatment. The wide field and hopeful outlook, the facilities and conveniences, and all the usual resources encountered in civil hospitals are entirely lacking, and the military medical service must be concerned chiefly with the saving of life and the removal of wounded men to military hospitals far from the combat zone. This is frequently the cause of differences in treatment so evident between civil and military practice.

If we are to understand the problems of jaw casualties, both with regard to prognosis and treatment, there are some elementary laws of mechanics which should be discussed briefly. Ballistics, the science of the motion of projectiles, involves certain laws of mechanics which bear directly upon the types and character of gunshot wounds. These laws involve factors of motion, velocity and energy. The flight or trajectory of a bullet from a gun or rifle as it moves through the air is influenced by two motions - translation and rotation. It is

acted upon by three forces—pressure of the powder gas which urges it forward, resistance of the air, and the force of gravity. The rotation of a projectile maintains its position in flight, keeps it from tumbling, and increases its range and accuracy of aim. However, at 1,000 yards rotation decreases and the bullet becomes unsteady. As the range increases this unsteadiness becomes more marked. This is of surgical significance, for it becomes obvious that the steady rotating bullet creates an entirely different wound from that of the long-range, unsteady, tumbling missile. These forces also influence the trajectory of a projectile, and it can be readily understood that they likewise influence and determine the type of wounds produced at various ranges.

The type of bullet also has a direct bearing upon the character of the wound.



Figure 1.



Figure 2.

The modern bullet, in traversing soft tissue, produces a track with less confusion and laceration than the old spherical missile. The entrance wound of the modern bullet has a punched-out appearance, while the exit wound is always slightly larger. Gunshot wounds involving bone disclose several types of conditions which vary with the velocity of the missile and the particular type of projectile. The modern bullet, at its highest velocity, most commonly comminutes the jaw into numerous fragments. (Figs. 1 and 2.) As a rule, the actual site of fracture is cleared of splinters, the fragments being forced into the soft tissue or out through the skin. These wounds frequently give the appearance of explosive effects and, of course, the exit wound may be of almost

any dimension. Large masses of bone fragments, muscular and tendinous tissue with adherent bone splinters, and bone dust, characterize the exit wound in the short-range, high velocity casualties.

At longer range the velocity is lower, and resultant casualties disclose considerable difference in the character of the wounds. The fragments are larger, fewer, and less displaced. (Figs. 3 and 4.) In gunshot wounds involving the fracture of bone, the exit wound is always larger than when no bone fracture exists. It has been established fairly well that any exit wound in the maxillo-facial region with a diameter equal to that of the thumb, is always indicative of a comminuted fracture with free splinters.

The track of a missile through the soft tissues must be given special con-



Figure 3.

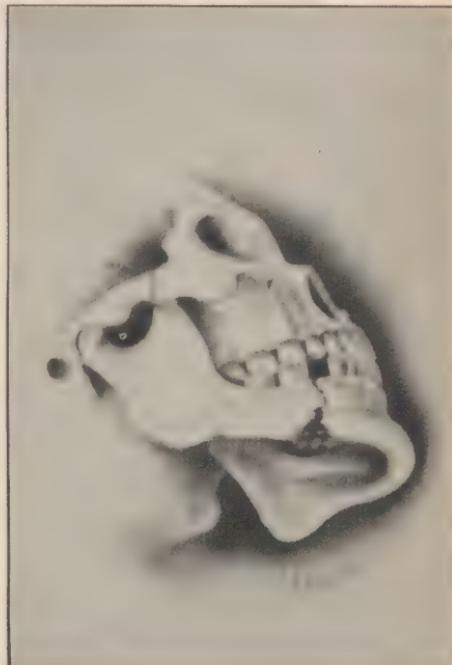


Figure 4.

sideration. The bullet produces a channel through the muscle which is similar to a tube. At short range this channel is somewhat larger than the bullet, but the size gradually decreases as the range increases. It is always larger than the entrance wound and the surrounding tissue is engorged with blood. Sudden enlargements at points where the bullet passes through tendinous structures will be noted. Tendons are usually split lengthwise of the fibers rather than cut across. A deformed projectile produces a wound so torn and lacerated as to destroy the continuity of both muscle and tendon.

The possibility of particles of clothing being carried into bullet wounds is of great surgical importance. Clothing, mud, dirt, and filth carried into battle

wounds are a dangerous source of infection. Experiments by La Garde show that rifle bullets are themselves sterile and their passage through living tissue does not cause septic infection within the bullet channel. The fact is accepted as a certainty, however, that sepsis arising from particles of clothing carried into the wound cannot be overestimated. Suppuration is sure to follow.

Wounds caused by shrapnel, shell fragments and hand grenades differ from the small-arms missiles. While the power of penetration of projectiles of this type is not very great, they are extremely destructive. The amount of laceration of the soft tissue is greater; the skin and muscles are irregularly torn and shreds or ribbons of these tissues hang from the open wound. (Figs. 5 and 7.) These lacerated wounds are usually greater in area than in depth and fre-



Figure 5.



Figure 6.

quently large fragments of the projectile may lie embedded in the wound. After their removal, it is found the soft tissues have been so lacerated and devitalized that they will not resume their normal relation to each other. We can then consider these particular types of wounds as more superficial than deep. They are always irregular, contused, and lacerated and are usually complicated by considerable shock and the lodgment of a foreign body. (Figs. 6 and 7.)

The primary symptoms associated with gunshot wounds call for our consideration at this time. Immediately upon being wounded symptoms of pain, hemorrhage, and shock are perceived, in the order named. While it is occasionally stated that men have been unaware of a wound until their attention

has been called to the fact, it is certain that pain is usually initially present in a majority of wounds. The intensity of pain depends upon site, gravity, and extent of the wound. When bone is involved or when there is laceration of the tissue, pain is usually severe. Later the wounds become numb and the pain lessens or disappears, only to return when reaction and recovery set in. As a rule, pain of great intensity, and of any considerable duration, is not common in gunshot wounds, and when present it is usually the result of involvement of large nerve trunks.

Nerve shock comes as a deadening sensation, all the affected tissues being insensible to touch, movement, and pain immediately upon being struck by the projectile. General or constitutional shock is common to all injuries, but is



Figure 7.

especially marked in gunshot wounds. It is most marked in penetrating wounds, in wounds involving the crushing and smashing of bone, and in severe wounds and contusions caused by large projectiles or fragments. The degree of shock varies with the severity of the wound. The mental state, nervous stability, or susceptibility, is an important factor in the development of shock. When all is well and troops are pressing on to victory, men will show little or none of the symptoms of shock. On the other hand, symptoms of extreme shock may be evident in consequence of a slight injury at other times. Occasionally shock may be so extreme that it is the direct cause of death. As a rule, however, the symptoms of shock increase with the gravity of the wound. The serious-

ness of shock and the importance of treatment require a special lecture on this subject.

Primary hemorrhage following gunshot wounds depends largely upon the missile, location, and tissues involved. Seldom is primary hemorrhage severe unless a large vessel trunk is involved. Even when a portion of an arm or leg is lost, often the hemorrhage is slight, considering the extent of the wound. Primary hemorrhage, however, is an important cause of death in battle, for a great majority of those who die succumb before aid arrives.

Injury to blood vessels constitutes the greatest cause of death in combat. It is estimated that 85% of all deaths in battle are the result of hemorrhage. The modern bullet causes clean-cut sections or perforations when the vessels are directly struck, and oval perforations when hit at a tangent. The lacerations caused by larger projectiles are severe and irregular. Damage to an artery wall by mere grazing results in sloughing and subsequent hemorrhage or traumatic aneurism. Direct injuries to blood vessels, caused by the missile, result in profuse primary hemorrhage, although their laceration by bone fragments, when fracture occurs, is probably a greater cause of injury.

These considerations are important to the military dentist because of his duty as an auxiliary medical officer, but particularly because of his responsibility in his special field. The large vessels of the neck are frequently involved in the face and jaw casualties, and their consideration is of special concern. Gunshot wounds of the neck prove to be rapidly fatal because of laceration of the great vessels, and serious interference with respiration and circulation caused by damage to the pneumogastric, sympathetic, and phrenic nerves.

Military surgeons frequently note the curious manner in which the large vessels escape injury when there is such certainty of their laceration. It appears that the looseness and mobility of the structures of the neck allow the vessels to yield or slip aside. Injury to the carotid arteries are usually immediately fatal. The indications for tying the bleeding points in cases of laceration of the vessels in the neck are more marked than in cases of hemorrhage elsewhere. Hemorrhage from the thyroid vessels is usually very profuse. Effusion of blood within the loose tissue causes pressure on the trachea producing dangerous interference with breathing.

In wounds of the neck, at or above the angle of the mandible, hemorrhage is usually very difficult to control. Either the internal or external carotid may be involved, and it is frequently difficult to determine from which of these sources it arises. Wounds of the internal jugular vein are very grave. While primary hemorrhage is usually the cause of death in the cases of involvement of the carotids, secondary hemorrhage or pyemia is the usual cause in wounds of the jugulars. The methods of treatment for wounds of the neck will be discussed in subsequent lectures.

Injury to the nerves of the neck, face, and jaws may be involved in gunshot wounds of the neck. The symptoms may be loss of motion, sensibility, and interference with the functions of the parts affected. Wounds involving the sympathetic usually prove rapidly fatal, for there are other complications, such as injury to the spinal cord, large blood-vessels, air passage, and esophagus. Wounds of the pneumogastric are usually accompanied by severe hemorrhage.

owing to the close relationship between this nerve and the carotid artery and jugular vein. Injury to the phrenic nerve causes symptoms of hiccups, a sensation of constriction around the body, and dyspnea from paralysis of one-half of the diaphragm.

Wounds of the larynx and trachea are usually perforations. Involvement of the large vessels is usually present when the wound extends laterally through this area. An antero-posterior direction of the missile will usually include laceration of the carotid trunks, fracture of the cervical spine and injury to the spinal cord.

Gunshot wounds of the face have our particular interest. While those involving the maxillary bones call for our special attention, our close and earnest efforts in conjunction with other specialists may also be required in the care of the related structures due to wounds of the ear, orbit, and nose, and the malar bones. Secondary hemorrhage, and suppuration, extending to the meninges, due to necrosis and lodged foreign bodies, are grave problems in the care of these casualties. Wounds of the maxilla frequently involve the sinus, buccal cavity, alveolar process, and teeth. (Figs. 2 and 7.) Great destruction and displacement usually attend such wounds and the laceration is most destructive, especially in cases of shell fragment, shrapnel and grenade wounds. Missiles penetrating the oral tissue often involve the tongue, but seldom do they lodge within its substance. When the mandible is struck by a high-velocity bullet, its compact substance splinters readily, and corresponding injury to the soft tissue results. The traumatism is still greater if the teeth and alveolar process are involved. In the wounds caused by long-range rifle fire, the bullets gutter or perforate the mandible with little splintering. Fractures of the upper portion of the ascending ramus and neck of the condyle are often comminuted and result in ankylosis unless the proper surgical care is given during the early stages of treatment.

The particular problems which concern the dental officer in the early treatment of gunshot wounds of the face and jaws require an extensive study of the surgical anatomy of the face and neck. This will become more and more essential as the surgical problems are presented in detail in the lectures which follow.

## LECTURE II

# THE SURGICAL CONSIDERATIONS OF JAW CASUALTIES

THE problems of surgery in war are very similar to the problems of traumatic surgery in civil life, except that the causes are usually different. The worst wounds in civil life are caused by automobile accidents, airplane crashes, et cetera, but they do simulate in many respects the severe injuries that are found in war-time caused by gunshot, shell fragments, hand grenades, rifle bullets, and other missiles of various kinds.

Wounds in general can be classified into different groups according to their severity. The simplest wound is known as an *incised* wound, in which the edges are clean-cut as if made by a sharp instrument, such as a knife, and in which there is no loss of tissue. (In such wounds the problems of infection very seldom arise.) Since there is no loss of tissue, the edges can be brought together without any special filling-in with new tissue, and healed by what is known as first intention or primary union.

In *lacerated* wounds the tissues are torn apart, and the edges are irregular and frayed. There may be some loss or devitalization of tissue around the edges. Other wounds are *contused* wounds, in which there is more or less a crushing of the tissue and consequently greater devitalization of tissue. The tissue dies, and part of it is lost from this cause in addition to that which is torn away at the time of the injury.

The tissue involved in a wound is an important consideration--whether the wound is of the soft tissue, or whether the underlying bony structures are involved also. In wounds about the face and jaws very keen judgment must be exercised in the preparation for treatment; that is, in determining the structures which are involved or injured, and in deciding what structures should be saved and whether torn tissues should be sutured. The conservation of all tissue possible is, of course, a primary consideration. In a wound involving the bone of the jaw as well as the soft tissues and in which the bone was shattered into numerous fragments, someone may have cleaned out everything that was loose, brought the soft tissues together over the resulting gap in the bone, and allowed healing to occur. Under such conditions the bone will not regenerate to fill in this gap. The fragments will collapse, and the jaw will be shortened, compared with its normal width. The soft tissues will heal over this shortened jaw, creating great visible deformity as well as interference with function, and the jaw will be useless.

Of course, the first consideration--the most vital consideration--in the care of any wound is the control of hemorrhage, because continued bleeding will result in the death of the patient.

Injuries around the jaws also often interfere with another vital function of the body--respiration. It is obviously important, therefore, to see that there is a free respiratory passage. In a wound about the jaw, for instance a wound going from one side to the other behind the mandible, the bone being severed here and some of it lost, the muscles of the mouth will contract and pull that

chin segment back, and the tongue and other structures will be carried back, obstructing the respiration. It is vital in such cases to hold the tongue forward and maintain a passage through the throat. One way to do this is to pass a safety pin through the tongue, tie a thread or string to the pin, and attach it to the clothing or dressing, thus holding the tongue out. (Fig. 8.) Another method which may sometimes be used is the passing of a piece of rubber tubing through the nose back to the pharynx or through the mouth to the pharynx, and this will help to maintain respiration. Certain forms of splints and wires attached to the teeth have been devised, whereby wires from the teeth can be attached to the head appliance to hold the anterior portion of the jaw forward.

Most hemorrhage around the face, unless very large blood vessels are involved, can be controlled by packing. Pressure is the best method of con-



Figure 8.

trolling bleeding. However, if the bleeding is too severe to be controlled by gauze packing, forceps may have to be utilized, although these are not always available.

Crushing wounds about the face (or anywhere else on the body) often produce a condition of shock. Shock is one of the things that requires early attention. The early measures for treatment of shock include: placing the patient in a recumbent position, in order not to allow the blood to come to the nerve centers in the head; relief of pain by sedatives (hypodermics will also tend to control shock); keeping the patient warm with blankets, available hot water bottles, et cetera. When the patient is taken to a place with more facilities,

plasma or blood transfusions, saline infusions, and other measures may be added to the treatment. Drugs are not usually of value in the treatment of shock.

Mention has been made of loose bone fragments and the actual cleaning-out of the wound. There are certain things which should not be done in the early treatment of war injuries, and cleaning out all loose bone is one of these. Any fragment of bone that has an attachment to the periosteum or muscular tissue should be saved if possible, because it may live and form a nucleus for new bone growth. It may form a bridge across the gap in the bone and help to form a new bone, whereas if everything is cleaned out, there will be a gap which cannot be filled by nature and which will require months of bone grafting and hospitalization to be filled surgically.

Nearly all lacerated and contused wounds are infected or become infected from the foreign elements carried in by the bullet or object which caused the injury: particles of clothing, dirt from the skin, dirt carried by a bullet that had ricocheted from the ground to the patient, scattered stones. There are several types of infection which may occur—staphylococci, streptococci, et cetera. The ordinary pyogenic organisms, of course, are always present. In addition, there are certain special infections commonly found in war wounds. The most common of these, of course, is the tetanus bacillus infection. Tetanus is almost invariably fatal once it gets hold in a patient; consequently patients who are actually wounded or who have had wounds in which tetanus is liable to occur should be protected by prophylactic doses of anti-tetanus serum. The tetanus bacillus is an inhabitant of the ground. Any ground that is under cultivation, particularly, contains the spores of the tetanus bacillus. Consequently, "street wounds"—wounds caused by objects or substances that have been in contact with the ground or street—are apt to be infected with the tetanus bacillus. This bacillus is an anaerobic organism. It produces a toxin which enters the nerve sheaths and attacks the central nervous system. The disease first manifests itself by a symptom with which you should be familiar. It causes trismus, a spasmodic contraction of the muscles of mastication. As the disease progresses, other muscles of the body are attacked, and the patient dies from exhaustion and toxemia. It has been found that after the infection has once entered the nervous system, it is almost impossible (and extremely rare) for any specific treatment at that time to overcome the trouble; the patient almost always dies. However, if the patient has been previously protected by tetanus antitoxin, the incidence of the infection is very much reduced, and if it should occur, there is some hope of curing the patient. In the last war, and in this present Army, the protection of soldiers against tetanus by the administration of prophylactic doses of antitoxin is a routine procedure. At the present time all personnel of the U. S. armed forces are given active immunization by the introduction of the toxoid of the bacillus, thus allowing patients to form their own antitoxin. A reactivating dose is injected at the time of injury.

Another infection which occurs in connection with these "soil injuries" so common in warfare is the gas bacillus infection—the bacillus Welchii. This is an organism which forms a gas in the tissues; it is very similar in its mode of action to the tetanus bacillus, not by attacking the nervous system, but by

causing a toxemia which develops very rapidly and which also is combated by means of an antitoxin.

After a wound has been sustained, the first stage of treatment is the arrest of hemorrhage and the covering of the wound in some way to protect it from further contamination until the patient can receive more thorough care. Often a foreign body is present in the wound—part of the bullet or missile which caused the wound, portions of broken-off teeth, clothing—but at this early stage it is unwise to do much probing for foreign bodies. This can wait until the patient is back in a safer place, where the wound can be properly localized and treated. Another important step, besides the application of the dressing, is the immobilization of the wound. Rest is also important in wound treatment, because it lessens pain, tendency to shock, and hemorrhage.

It is essential to protect these wounds against further injury. The transportation of a patient with a wound of the face or jaws thus becomes a very serious problem. Many patients have been picked up on the battlefield and placed on a stretcher or in an ambulance while still alive, but upon arrival at destination were found to have died, due to failure of respiration because the position of the patient had not been favorable. These patients with face and jaw injuries should, when possible, be transported without lying down. They are much better off sitting up; their respiration is freer. If they must necessarily be taken in an ambulance or on a stretcher in a reclining position, they should not be on their backs, since this position favors the collapse of tissues back into the pharynx. The patients should be placed face downward or well over to one side. This will help to keep the air passages free and will allow mucous and blood collecting in the throat to be expelled.

Infection can be combated to some degree in the early treatment of wounds. This is probably simpler in wounds away from the mouth, which is a constantly infected area, full of bacteria. A wound of the mouth cannot be made absolutely sterile, though it is remarkable how such wounds will heal in spite of this. There seems to be some influence which counteracts the bacteria and infection. Wounds in other parts of the body can be isolated, theoretically, at least. In some cases infected tissues have been cut away early, leaving a wound in an ideal condition, not infected, so that it will heal by primary intention. This is known as debridement—the cutting away of shreds of devitalized tissue and tissue that has been contaminated on the surface—and gives ideal conditions for quick healing. This treatment is useful for wounds in most parts of the body, where there are fewer fine structures which might cause trouble if cut away. About the face and mouth you must be more conservative with the tissues. You must consider facial nerve fibers, salivary gland ducts, and you cannot cut away large amounts of tissue without causing serious trouble, in addition to the disfiguring scars which would result. Therefore debridement is not of very great value about the face.

There are other measures which can be used to combat infection in wounds. The first World War saw the development of the process of debridement and the Carrel-Dakin treatment. That was a solution of hypochlorite of sodium used to bathe the wounds continuously until cultures showed that the wounds were sterile, and could then be closed with sutures. This Dakin's solution

was passed through irrigating stands continuously, a few drops at a time, through perforated tubes into the wound, until the infection had cleared up both clinically and according to culture methods. Various germicides have been developed, such as acriflavin and mercurochrome, which have proved of some value. More recently certain oxidizing agents have proved of value in deep streptococcal infections: especially, peroxide of zinc powder, which has to be specially prepared and activated. It is mixed up with water or a salt solution into a cream, and this is applied to every part of the wound. Good results have been obtained on bad sloughing wounds due to the streptococcus and gas bacillus. We also have sulfanilamide and allied drugs which have proved of great value in streptococcal and also in staphylococcal infections. Sulfanilamide has been used in various ways—hypodermically and also by mouth. It is chiefly used by mouth at the present time, and is administered until a certain level is reached in the blood which will have the desired effect. It is used more particularly where bacteria have entered the blood stream and caused a general septicemia. It has been suggested that every soldier have a supply of sulfanilamide with him, to take immediately as a prophylactic in the event he is wounded. Sulfanilamide has been used locally in wounds rather extensively in armies abroad. Studies are now being conducted here to determine whether this treatment is of real benefit. Comparison studies are also being conducted with drugs of the sulfanilamide group and other drugs. These studies are for the purpose of determining which drugs give the best effect and control under certain conditions, and it is hoped that some real results will be obtained.

#### SUMMARY

*Early Care of Face and Jaw Casualties:* (1) Insure free respiration, if necessary, by turning the patient on his face, or by tongue traction.

(2) Lay recumbent casualty with mouth bleeding in the prone position until bleeding can be controlled.

(3) Remove no attached fragments of bone, and reposition displaced face fractures as early as possible, breaking up impactions where necessary, and restoring occlusion and nasal breathing space. This should be done within the first two weeks, the earlier the better, after shock has been controlled. Call the dental surgeon in conference for all fractures of the mandible or maxilla.

(4) Do no debridement of soft tissues of the face, but readjust large cuts, tears or displacements by means of deep tacking sutures as conditions permit. Immediate tacking of the mucosa to the skin to cover the raw tissues is often helpful. Except for the eyelids and lips where it can be done by immediate suture, leave the ultimate repair to those working in base or special hospitals. In this way much ultimately usable tissue may be conserved and permanent disfiguring suture scars avoided.

(5) Do not entirely close through and through wounds of the floor of the mouth, but where advisable the mucosa may be sutured, the depth of the wound being packed from the skin surface below. This will avoid phlegmonous spreading infections of the floor and neck.

## LECTURE III

# THE DENTAL CONSIDERATIONS OF JAW CASUALTIES

OUR consideration of the dental surgeon and his acceptance of his responsibilities in connection with the jaw casualties is of great importance in the immediate emergency treatment and the ultimate results of our wounded in time of war. The recognition of this important consideration affords us a sounder approach to the problems of jaw casualties in our medical service. Regardless of the unusual experience and skill of the surgeon in the care of war casualties, an approach to a happy solution of jaw casualties without the aid of trained dental surgeons cannot assure favorable prognoses in their treatment. It will become increasingly evident that the more serious the jaw injury, the more important is the responsibility of the dental surgeon. In time of war, many general surgeons will be called upon to render first aid treatment without the assistance of a dental surgeon. The surgeon is utterly helpless beyond the first aid measures. Even in rendering the first aid treatment, he will be at a loss to effectively care for the jaw casualties with that assurance he possesses in the care of wounds of other parts of the body. This is due to his lack of knowledge relative to the dental structures and the steps which must be taken to assure the restoration of function. It is therefore important that a large number of dental officers be trained to meet the particular problems encountered in the first aid and emergency treatment in the care of jaw casualties, and that they understand their responsibilities in their work with the medical officers on the battlefield. It is frequently observed that the oral and plastic surgeons have been tremendously handicapped in their reconstruction work owing to the lack of consideration on the part of uninformed general surgeons who have rendered first aid treatment for jaw casualties. The effective efforts of dental surgeons in combat units on the battlefield in the early treatment of jaw casualties will assure the oral and plastic surgeons ideal results in the reconstruction and restorative measures which follow in the hospitals in the rear.

The primary consideration for the dental officer in the early treatment of every jaw fracture must be the ultimate restoration of dental function. The early treatment should be such as to assure every chance for the restoration of original occlusion or the restoration of function, even in those cases with loss of considerable bone. It is particularly important to avoid the collapse of bone segments. Many of the horrible deformities resulting in past war experience because of failure to maintain bone segments can be avoided in the future, if the dental officer renders the proper type of treatment at the first aid and emergency stations. Often bone particles which still possess periosteal attachment may be useful in the later stages. It must be remembered that the conservation of small particles of bone with living attachments may make all the difference between new bone formation and the restoration of function, or the collapse of fragments and the attendant complications. Even comminuted, viable bone should be saved.

The clinical picture of gunshot wounds of the face and jaws cannot fully be appreciated at first—the battered, lacerated, displaced and bleeding structures can only be gently bandaged, air-way established, and hemorrhage controlled as first aid measures prior to movement to the collecting station or casualty clearing station. In all these first aid measures the dental officer must also consider his particular responsibility as the conservation of dental structures, regardless of their injury, in the hope that the final reconstruction can assure the wounded soldier a face presentable to society and jaws which may function when the restorative measures have been carried out. Reduction and fixation can only be of a very simple type in early treatment. Stabilization of bone segments will give assurance of some ultimate restoration of occlusion if applied intelligently. It is essential also to reduce pain and control shock. Stabilization helps to avoid recurrent hemorrhage and to facilitate recovery. Final weaknesses in any plan for the treatment of jaw fractures in the combat zone may be overcome by the selection of simple but adequate measures and by the universal training of all medical personnel of combat divisions in the need for and application of sound and adequate methods of emergency treatment. First aid treatment for these cases is not solely a responsibility of the dental officer, but early observation by a dental surgeon is most desirable. It must be remembered that the object of early treatment is to sustain life and to restore the casualties to duty after a minimum period of hospitalization. Beyond this there is the natural desire to later restore them to civil life as functionally useful and desirable members of society. The results are usually directly proportionate to the nature and character of the emergency treatment received, and these final results should be the greatest concern of both medical and dental officers in the early treatment and fixation of jaw fractures in time of war.

## LECTURE IV

### FIRST AID FOR JAW CASUALTIES

THE characteristics common to all jaw injuries in war have been mentioned. There are special considerations which are worthy of our attention at this time, for their significance is extremely important in early treatment. The clinical picture of gunshot wounds of the face and jaws in war cannot be fully appreciated at first. The battered, lacerated, displaced and bleeding structures can only be gently bandaged as first aid measures prior to transfer to the medical installations in the rear.



Figure 9.



Figure 10.

The three most important measures in first aid treatment of gunshot wounds of the face and jaws may well be: (1) Control of hemorrhage; (2) Clearance and maintenance of air way for respiration; (3) Stabilization of parts.

Each of these measures is of utmost importance and should be instituted as early as possible and with efficiency. They are imperative for the conservation of life. Other measures also are of grave importance, but will be considered after this first aid stage.

*Hemorrhage:* In order to save life, a rather rapid and hurried examination should be made, remembering that war casualties frequently have multiple wounds, and hemorrhage must be brought under control promptly. Considering arterial hemorrhage the most serious, it should be arrested at once by

digital pressure, if possible, until more effective means can be applied. Dangerous wounds, with bleeding in the extremities, can be brought under control by the use of a tourniquet, but wounds of the face or neck require other procedures.

One must be familiar with the most effective points for the application of pressure to control hemorrhage of the face and neck. With the use of gauze and bandages can be applied over these areas and bleeding controlled until a clamp or ligature is applied to the injured vessel. Hemorrhage from the external carotid and its branches may be temporarily controlled by digital pressure applied along the anterior margin of the sternocleidomastoid at the hyoid bone. (Fig. 9.) The pulsation should be located and sufficient pressure applied inward and slightly posteriorly to compress the lumen of the vessel, thereby



Figure 11.



Figure 12.

minimizing the loss of blood until terminal bleeders can be controlled. Hemorrhage within the supply of the external maxillary artery may be reduced by compressing the vessel where it crosses the lower border of the mandible in the notch just anterior to the angle. The most effective point to compress the superficial temporal artery is where it crosses the zygomatic process of the temporal bone just anterior to the ear. The lingual artery can be controlled to some extent by deep pressure under the angle of the mandible, or in severe cases by compression of the external carotid. Pulling the tongue forward over the teeth may be effective and, in cases of loss of a portion of the mandible, the dorsum of the tongue can be compressed between the thumb and fingers.

Hemorrhage from soft tissues should be cared for with sutures when possible and excessive bleeding from the bone can be controlled by tissue or gauze held over the part under moderate tension (suture tension if available, digital tension in grave emergency). It may be necessary to pack gauze into the wounds to check inaccessible bleeders, either suturing it in place or bandaging in position under pressure, the prime object being to conserve the individual's blood supply, prevent shock, better prepare these serious cases for transportation to the next station, where more exacting measures can be instituted to save life.

*Respiration:* Severe wounds of the face and jaws frequently interfere with respiration. Establishing an airway may be the first consideration of treatment. Fragments of bone, fractured teeth, fillings, broken dentures, particles of clothing, soft tissue and blood often drop into the posterior part of the



Figure 13.



Figure 14.

mouth and throat. Frequently some foreign bodies are aspirated. The patient is confused, fearful, choking, or unconscious and the reflexes and reactions dangerously disturbed. Obstructions must be removed immediately and the fractured bones or disorganized tissues should be adjusted so as to assure adequate airway. Having removed all foreign bodies from the mouth attention should be given to the immediate control of bone fragments and soft tissues which may drop back into the throat. Fractured superior maxillary bones must be adjusted anteriorly to avoid blocking the nasal and mouth airway by posterior displacement. Gauze properly placed between the posterior teeth

may give temporary support; however, extraoral anterior traction may be necessary to accomplish a satisfactory result.

The tongue falling backward due to loss of its attachments to the mandible may block the airway. A suture through the tip of the tongue may be necessary to control this factor. The ligature can be controlled by the patient or fastened to clothing or a dressing for extraoral traction.

*Stabilization of Parts:* Having secured temporary control of the first two dangerous problems to maintain the patient's life, consideration can now be given to stabilization of the bone fragments and displaced soft tissues. Conservation of tissue is of utmost importance. Bone fragments that have any possible periosteal attachment should be preserved; likewise, all the mucous membrane and skin that can be saved is extremely useful to suture over the



Figure 15.

torn ends after the thorough debridement. Whatever fixation that can be accomplished as a first aid measure is important and helpful to prevent recurrence of hemorrhage and to maintain free airway. This stability of parts is also of extreme importance to the patient in reduction of pain and discomfort. The several dangerous hours ahead through which the patient must pass are greatly influenced by the first aid treatment, and application of these three major considerations is of utmost importance. Perhaps one of the most important results of careful and thorough first aid treatment is to minimize shock.

It must be borne in mind that the jaws not only give form to the face, but also support the dental structures. Simple measures should be applied to main-

tain the bone segments in position, so that function may be restored later. Lateral segments should be stabilized, in case the chin or a portion of the jaw is shot away. Collapse of lateral segments, failure to conserve mucous membrane and skin by suturing, lead to a pitifully disfigured result with loss of function. The value of proper and thorough treatment by the first aid personnel cannot be overestimated.

The lateral segments of the mandible can be simply and easily stabilized by intermaxillary fixation (using elastics for traction and fixation if available).



Figure 16.



Figure 17.

If the injury to the maxillae produces a distal displacement or is impacted, use can be made of extraoral traction. Likewise, if the fragments of the mandible are displaced distally, anterior traction can be applied. Attachment can be obtained by wires around the teeth in the segments, and in case of missing teeth, the suture or wire can be placed through the tissues or bone to be supported. As suggested previously the tongue can be effectively supported by a suture through the tip and elastic traction using the same type of appliance.

Stabilization of the many varieties of fractures of the jaws will tax the ingenuity of the dental officer. Bandages, adhesive tape, safety pins, rubber bands and wire will provide the means for many different methods of simple fixation and stabilization of parts. (Figs. 10 and 11.) The use of these same materials will not only provide support for displaced structures of the face, but will assist in control of hemorrhage and maintenance of airway.

First aid treatment must be simple, conservative, effective, and quickly accomplished, having the greatest regard for the patient's welfare and comfort.

Many jaw cases, complicated as they are, will also be associated with other wounds, and must be transported by litter to the rear. As a rule and a safety measure, serious jaw cases should not be placed on their backs on a litter. Recurrence of hemorrhage or blocking of the airway may result in death. The patient should be placed on his side or, in some cases, on his stomach.



Figure 18.

#### FIRST AID BANDAGES

The first aid packet consists of a bandage and compress which is admirably adapted for jaw wounds. By slitting or tearing the tails of the bandage, toward the compress, the tails of the bandage may be applied in such a way that the compress may be adjusted at the symphysis to support the mandible or fragments. The tails of the bandage are crossed so that the inferior one may be brought up over the temporal region and tied well forward with the other tail from the opposite side. The tails of the bandage from the point of the chin are directed backward, above the ears, and tied above the occiput. The four end-tails are tied as shown in the illustration so as to maintain the dressing. (Figs. 12 and 13.)

#### MODIFIED GIBSON BANDAGE

This type of bandage provides support without any backward displacement of the mandible. It consists of ordinary two-inch gauze, wound around the mandible and over the head and stabilized by a bandage around the head and by adhesive plaster. This bandage may be modified further by the use of elastic

traction for cases of marked displacement or for the support of injured maxillae when the mandible is intact. (Fig. 14.)

#### PARKER BANDAGE

This bandage consists of the usual two-inch gauze and is somewhat similar to the Barton bandage. The gauze is applied first and two inch adhesive strips adjusted over the gauze; cardboard strengthens the adhesive for support of the safety pins, avoids collapse when the elastics are applied. (Fig. 15.)

The importance of the position of the patient on the litter is obvious. The illustrations indicate the most desirable and safe litter positions for jaw casualties. (Figs. 16, 17, 18.)

## LECTURE V

### EMERGENCY TREATMENT FOR JAW CASUALTIES

**V**ITAL weaknesses in any plan for the treatment of jaw casualties may be overcome by the selection of simple but adequate equipment and by the universal training of all medical personnel of combat divisions in the application of sound methods of emergency treatment. These considerations are essential from our regimental medical installations through the various stages of evacuation to our large hospital units.

It is presumed that first aid treatment has been rendered for the jaw casualties in the battalion aid stations or other forward echelons. At the casualty



Figure 19.



Figure 20.

clearing station (or hospital station) the patients are prepared for evacuation to the rear. This may mean several hours of unattended travel. For this reason, special attention must be given to the jaw cases to assure safety during travel. The adjustment of dressings and bandages, the immobilization of parts, the checking of clear airway, and the definite control of bleeding points by ligation are matters of extreme importance. Treatment for shock must not be neglected in one's haste to evacuate the casualties to installations in the rear. (Figs. 19 and 20.)

The first aid officers and men in the regimental areas work under the most trying conditions and with limited supplies. When jaw casualties reach the

casualty clearing station, it may be necessary to remove the first aid dressing and render adequate emergency care. Hemorrhage may have continued and ligation may be necessary. The examination of the wound may disclose particles of teeth, bone, or foreign bodies which might easily be aspirated. Steps must be taken to immediately correct these possible difficulties. There may be signs of shock which require immediate treatment. There may be indicated needs for surgical interference before the patient is transported by ambulance to a hospital in the Communication Zone. These are some of the important factors which influence the emergency treatment required prior to evacuation.

For the control of hemorrhage, first aid treatment may have been the use of a pack or the application of a clamp. (Figs. 21 and 22.) The pack will fre-



Figure 21.



Figure 22.

quently control the hemorrhage from bleeders, but at the casualty clearing station these bleeding points should be located and tied off. Frequently it may be necessary to use a clamp to control hemorrhage from a larger vessel. Before any long ambulance trip, more satisfactory measures must be taken to definitely control hemorrhage by ligation. The ligation should always be made as close to the break in the continuity of the blood vessel as possible. A thorough understanding of the blood supply to the tissues, identification of the injured blood vessel, and other considerations are important. Ligation of a large vessel, far from the point of injury, may cut off the blood supply to the soft tissues and cause their total devitalization before collateral circulation is established.

Again, it is of great importance to permanently control hemorrhage to safeguard the patient against shock.

Upon careful examination, it may be found that more adequate measures can be taken to reestablish original occlusion and immobilize the fracture. The dental surgeon's most important personal responsibility is to so apply the simple measures of temporary fixation that it will assure restoration of original dental function. This may be impossible except for only one segment of either dental arch. Adequate measures must be taken to prevent collapse of the fragments or even one remaining fragment if all else is destroyed. The success attained in the surgical treatment later may be due to the thoughtful emergency treatment rendered at the advance casualty clearing station.

Fixation may be secured in several ways. The measures discussed under



Figure 23.



Figure 24.

first aid treatment may suffice. It may be possible to use intramaxillary wiring with intermaxillary elastics. This method will be discussed in detail in a subsequent lecture. Under no circumstances should intermaxillary wiring be used. This method is *dangerous* for war casualties, and especially so prior to unattended travel.

There is another phase of emergency treatment which demands serious consideration. Many casualties brought to the casualty clearing station require immediate surgery. These cases are termed nontransportable; their wounds are so serious that they would die unless emergency surgery is resorted to immediately. Others are in a state of shock, and treatment must be instituted

without delay to save life. These patients cannot receive the necessary surgical care at the casualty clearing station, and mobile surgical and evacuation hospitals are established within a few miles of the casualty clearing station to provide the necessary facilities for the care of these nontransportable casualties.

Maxillofacial teams will be attached to these surgical and evacuation hospitals to care for the serious jaw casualties. The skillful work of specialists in jaw surgery available in the field surgical units will assure us the proper care for these serious jaw cases. The elaborate facilities of great surgical hospitals will not be available near the front, but skilled surgical personnel, even with limited equipment, can provide those urgent necessities for the early surgical treatment of the most seriously wounded.

Through the entire combat area every attempt is made to provide the trained personnel to care for jaw casualties. The first aid treatment is simple, but does provide means of saving life. The emergency measures particularly are broadened in scope to prepare the wounded for the miles of unattended travel to the large hospitals in the Communication Zone. While the large medical facilities provide for the general care of all wounded, special auxiliary surgical groups are also included, one of which provides early surgical care for jaw casualties. Medical and dental officers make up the essential teams in every echelon of medical installations, and this effective teamwork is most reassuring to the Army. It is far more desirable to pool surgical skill and fine dental discernment to secure favorable end results. These principles are essential from our regimental medical installations through the various stages of evacuation to our large hospitals. The object of this careful treatment is to save life and to restore the casualties to duty after a minimum period of hospitalization. Beyond this is the national desire to later restore them to civil life as functional, useful, and desirable members of society. The results are usually directly proportionate to the nature and character of the emergency treatment received. These end results are the greatest concern of our medical and dental officers responsible for the emergency treatment of jaw casualties.

## LECTURE VI

### THE REGIMENTAL DENTAL OFFICER

THE experience of the regimental dental officer clearly indicates the difference between civilian practice and the routine duties of the military dentist. The military dental surgeon is one of a team; he represents but one part of a great medical service in which the team-work and unity of purpose assures the successful efforts for the maintenance of the health of troops.

The regiments are usually provided with two dental officers. While they are provided with field equipment and dental supplies sufficient to accomplish a



Figure 25.

great variety of restorative work and the usual simple extractions, it is not expected that the duties of the regimental dental officers will be limited to dental service alone. In camps, at training centers, and rest areas, this dental outfit, M. D. Chest, No. 60, will be set up in the regimental or battalion dispensary. Here the usual dental emergencies will be attended at stated periods each day. (Fig. 25.)

This new equipment consists of a single medical chest and contains chair, engine, instruments and supplies. The all-metal chair can be set up in less than a minute. The foot engine is the same cord-type engine that was universally used a score of years ago. The instruments have been carefully selected

and are made of stainless steel. Many of the latest instruments and supplies are furnished in the field outfit. (Fig. 26.)

Except in emergencies, dental treatment of a definitive character will usually be given at the fixed dental installations adjacent to the regimental area. This may be in camp dental clinics or station hospitals.

The regimental dental officer is concerned with the dental health of his regiment. At the training camp he will make a survey or examination of his regiment. This will be sent to the camp dental clinic where all the necessary definitive treatment will be accomplished during the months the regiment is in training. He will initiate the usual steps to encourage oral health habits among his troops. He will maintain his small but efficient dental installation in the



Figure 26.

same clean and efficient manner that he would his office at home. He will display the usual care and skill in his dental service. The same careful and accurate measures are essential in the dental service of the Army whether it is rendered in some temporary camp or at some elaborate clinic or hospital.

In fact, meticulous care is exceedingly important in camp dental installations. The care in the preparation of the syringe and handling of the carpule are very important. Many serious complications have arisen, due entirely to carelessness in the routine preparation and injection of the anesthetic prior to extraction. The control of epidemics of stomatitis, particularly of Vincent's infection, is a responsibility of the regimental dental officer.

The dental officer is a Medical Department officer. This naturally implies that he should be available for other duties, essential for the proper operation of the regimental medical detachment. These other assignments might require administrative responsibilities or even a wide variety of professional service as an auxiliary medical officer. Under the supervision of a medical officer, the dental officer can often substitute for other medical officers. Occasionally, the dental officer will be the only officer available to assume charge of a battalion aid station or the medical detachment. In camp there are boards, courts, and other special duties to which the dental officer may be ordered to serve in some capacity. The large number of routine duties to which the dental officer may be assigned in camp, on the march, or in combat



Figure 27.

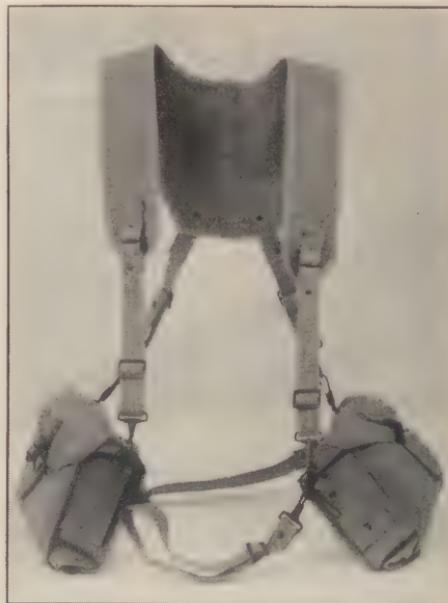


Figure 28.

make his value to the medical service more and more important as he gains experience.

The training program for the Medical Department officers assigned to the regimental medical detachment anticipates this added duty, for the dental officer can be exceedingly valuable to the regimental and battalion surgeons. Intelligent dental officers can meet these exceptional demands and their close application to the training program during the training period will add to the value and efficiency of the Medical Department. This is our additional contribution as dental officers.

The necessity for such a broad training becomes apparent when we consider the great tasks confronting the regimental medical detachment in combat. Every available officer and enlisted man must attend the wounded. The idea

of a dental officer devoting any time to routine dental service is absurd; the thought of the dental officer remaining in a rest area, far behind the battle area cannot be justified in any honest opinion. The dental officer must share the dangers and hardships with his brother officers just as he enjoys all the advantages with them.

Prior to moving into the combat zone, the camp dental equipment (M. D. Chest, No. 60) is stored with other medical equipment at the point designated. This is usually near the rest area. All division equipment not required in the combat zone is usually left at a place, designated as the division dump. It may be in some building but is usually piled up and covered with tarpaulins. The



Figure 29.

regimental medical equipment, baggage, etc., is stored in this fashion and a guard posted to protect it.

The dental officer takes his individual dental kit with him when accompanying his regiment into combat. (Fig. 27.) This equipment consists of a small bag with shoulder sling and the enlisted assistant carries two similar bags. (Fig. 28.) The contents of these three small bags provide instruments and supplies necessary for extractions and other simple emergency dental treatment. (Figs. 29 and 30.) These kit bags also carry a large number of first aid packets, dressings, hemostats, suture needles, suture material, scissors, tissue forceps, scalpels, morphine, and adhesive tape for the first aid treatment of gun-shot wounds of the face and jaws and other battle casualties. (Figs. 29 and 30.)

The service of the regimental dental officer is varied; it is exceedingly interesting. The duties are exacting and frequently exciting. The regimental dental officer will experience endless change, colorful and thrilling assignments, and the genuine fascination which has called the soldier and the adventurous spirits of men for ages. The trust and confidence which men share; the endless routine and the grim and silent moments preceding battle; the din of battle and the dangers of conflict are all his to share with the officers and men



Figure 30.

with whom he has served for months. But there is even a richer experience that falls to his lot. War is a destructive force! It is the privilege of the regimental dental officer to join with his brother medical officers, in bringing a healing power wherever duty calls. This is the greatest call for service. Make it a service in camp or in combat that equals all the traditions of our great Medical Department.

## LECTURE VII

### THE MAXILLO-FACIAL TEAMS

THE major purpose of this series of lectures is to present the problems confronting the dental officer in the treatment of gunshot wounds of the face and jaws. These problems constitute the greatest departure from the usual experiences of civilian practice. The primary problems have been presented. The vital and important tasks which will be encountered and the latest methods for first aid and emergency treatment have all been discussed. The considerations have illustrated the dental responsibilities and also clarified the essential teamwork between the medical and dental officers.

There has been but little reference made to the various medical units which make up the chain or echelon of establishments through which the battle casualties pass as they are transported from the front to the great hospitals in the rear. The organization of these various units is not within the scope of this lecture, except to mention their importance as related to the jaw cases.

The whole purpose of medical service on the battlefield is to save life and to rapidly move the casualties to hospitals in the rear with the hope that surgical care in the hospitals will result in the early restoration of the wounded to a duty status. A steady flow of casualties to the rear by ambulance and hospital train effects this rapid evacuation of wounded and assures early treatment, so vital to them.

There are, however, many serious casualties, so severely wounded that they cannot be transported to the hospitals far behind the front lines. Facilities must be provided for their immediate surgical care in the combat zone. The more serious jaw wounds are among those which must frequently receive special surgical attention at some mobile hospital installation before being sent on the long trip by train or ambulance to a hospital in the rear.

To provide the specialists required for face and jaw surgery, provisions have been made for maxillo-facial teams. In fact, these teams, attached to mobile medical units in the combat zone, are similar to the maxillo-facial units which are to be found in the general hospitals in the rear, except that they are organized as small units, their equipment is very limited and their function is solely that of early surgery for jaw cases. Many other special groups are provided for other special types of surgery and all these special groups are available to send to any medical installation in the rear of a division on the battle front as the needs may arise.

As a rule, these special or auxiliary surgical teams are sent forward to the surgical and evacuation hospitals which may have been established behind a front line division heavily engaged with the enemy. The seriously wounded jaw casualties are given the needed immediate surgery by the maxillo-facial surgical team. Upon the completion of the operation they are placed in one of the tent wards where the required attention is given until they are improved enough to be transported to a general hospital in the communication zone.

The maxillo-facial team consists of an oral and plastic surgeon (Medical Corps) and a dental oral surgeon (Dental Corps), together with nurses and an

enlisted technician. The maxillo-facial teams, together with the other special or auxiliary surgical teams, belong to that larger group of medical units under the control of the chief surgeon of the field army. Upon the request of division surgeons in the combat zone, these teams are ordered to the particular points where needed and attached to the field units operating at these locations. When their tasks are completed, they return to the medical headquarters of their particular army. After a period of rest, they are again available for duty when and where needed.

The equipment provided for the maxillo-facial teams has been carefully selected. It must be remembered that medical units operating in the field must limit their equipment to the bare essentials. In every hospital in the field, there will be found an ample supply of the usual surgical equipment. It is therefore



Figure 31.

only necessary to provide these maxillo-facial teams with the instruments and equipment essential for their particular surgical work. Carefully selected forceps, curettes, elevators, pedicle needles, and special tissue forceps are to be found in the maxillo-facial kit. (Figs. 31 and 32.) Arch wire and special supplies for ligation and maxillary fixation are provided. The kit also includes all the essentials for block anesthesia. There are certain to be cases requiring a general anesthetic—equipment and supplies for this will be available at the hospital when needed and is not a part of the maxillo-facial kit. For some cases it may be desirable to use intravenous anesthesia but for many jaw cases it is contraindicated, especially those wounds involving the tongue.

The functions of the maxillo-facial teams, temporarily assigned to surgical or evacuation hospitals, are careful and detailed examination and the preparation of the patient for safe evacuation to the rear. Hemorrhage is controlled by ligation of troublesome bleeding points; adequate measures for temporary fixation, treatment of shock, transfusion, etc., are applied.

The casualties are examined to determine the extent and nature of the soft tissue and bone injury. The wounds are cleansed and all foreign bodies—pieces of the missile, stones, clothing, dirt, etc., that can be discovered—are removed. All detached bone splinters must be removed; teeth and portions of teeth that have been displaced and carried into the soft tissues should be removed since they invite infection. Loose bone fragments with soft tissue attachment *must* be preserved. These particles of bone frequently provide valuable osteogenetic centers for the framework of the regenerating bone which re-

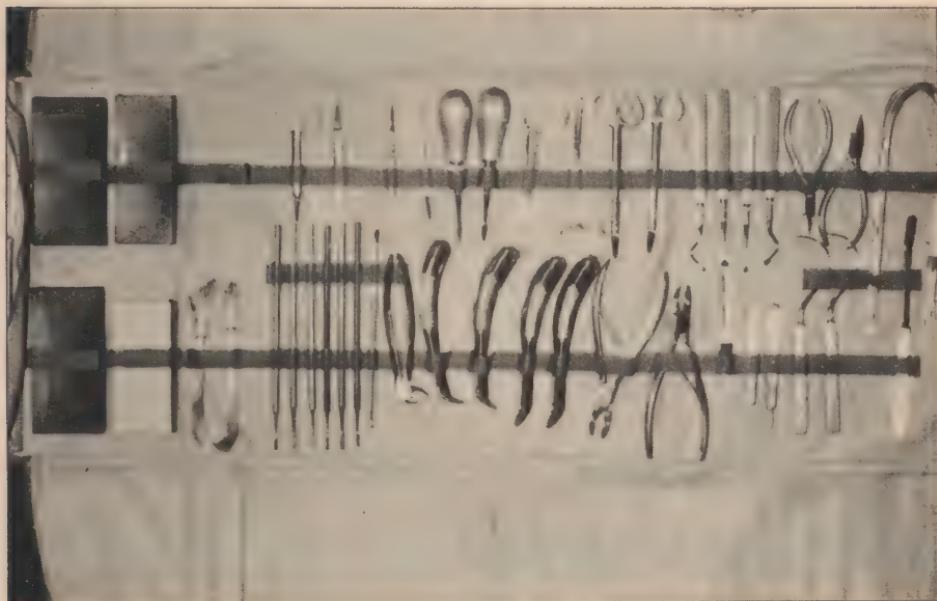


Figure 32.

places the lost bony tissue. Removal of all loose bone in such cases will often cause needless surgery, result in disfiguring defects and even destroy those essential elements of tissue by means of which nature can assist in the repair of damage to both soft tissue and bony structures. Leave bone fragments of doubtful vitality and remove later if sequestration occurs. All loose teeth and roots communicating with the line of fracture are removed at this time. If the survival of a tooth is doubtful, especially if it is useful temporarily for the stabilization of fragments, its removal should be deferred.

Reduction and temporary fixation of the bone fragments in approximately original position should be done at this time. If sufficient teeth are present in each fragment of both arches, this may be done with arch wires and ligatures.

This method, in conjunction with the dressing and bandages, will maintain the injured fragments at this stage of treatment.

If the fracture is comparatively simple and there is no difficulty in maintaining the airway, with little injury to the soft tissues, intermaxillary fixation by means of the continuous wire loops in both arches and elastic traction will provide the best stabilization.

The dressing and bandage must be applied with great care. The soft tissues must be placed in approximately normal position. Adequate measures must be taken for the comfort of the patient, remembering that these cases are extremely serious, usually in need of transfusion, and must be given extremely careful treatment if they are to survive. Their safe removal to hospitals in the rear may depend largely upon the attentive care at this time.

The function of the maxillo-facial teams in the combat zone has been pre-



Figure 33.

sented, but it might be well at this time to present something of their functions and more elaborate organization in the general hospitals. War wounds are almost universally infected wounds. The casualties must pass through weeks of hospital treatment which may be divided into phases. It is obvious that infection must be cleared up before any reconstructive surgery can be undertaken. It is apparent to all that the definitive surgical intervention will usually require several operations to reestablish the bony structures so that the functions of mastication can be restored and there must be several plastic operations for the restoration of facial structures. Finally, there must be the dental restorative measures.

It can be seen that the great demands for maxillo-facial surgery require elaborate facilities in each phase through which the wounded soldier must pass

in order to restore him to duty or to return him to civil life as a presentable individual in society.

During the septic stage many serious and dangerous complications arise. The attentive care of trained personnel is absolutely necessary to successfully cope with the various emergencies and to clear up the infection of soft tissues and bone which always accompanies war wounds. Through this long period the dental surgeon must ever maintain special care of the dental structures to assure the most favorable results in the final restoration of dental function.

The reconstructive surgery is never undertaken until all infection has cleared up. In the World War, many of the jaw casualties requiring reconstructive surgery were returned to the United States. This decision was desirable for those who would not be returned to their combat units. Other cases remaining in France were moved to large surgical services and away from the septic surgery wards. The various phases of this stage of treatment require elaborate facilities, both surgical and dental. Supporting the surgical personnel must be the dental specialists—orthodontists, prosthodontists, technicians, and other members of the dental and medical services so essential for the most effective results. The equipment not only includes the most complete facilities for surgery but also additional dental facilities to meet the unusual demands for the many varieties of dental care.

Special training is necessary for the maxillo-facial teams and for all the supporting personnel. Plans for this training have been outlined and completely developed in The Surgeon General's Office. It is particularly necessary to provide training for the oral and plastic surgeons to meet the many emergencies which will arise in this service. The complete development of maxillo-facial surgery to meet the demands in time of war require comprehensive training for dental oral surgeons. In all this training there must be developed a spirit of teamwork to assure maximum results.

Apropos the teamwork mentioned, some dental surgeons have raised the question of surgical and dental responsibility of jaw cases. Very honestly, the questions have been asked, "Who is responsible for the surgery?", "Who is responsible for the ward care of the jaw cases?" There is only one answer—the medical officer is responsible for the surgical procedures and ward care. The dental officers are responsible for the dental treatment. The responsibilities are closely interwoven through a splendid teamwork. The whole spirit of this teamwork is to assure a better surgical result by pooling the knowledge and skill of the oral and plastic surgeon with that of the dental oral surgeon. The end results desired by the dental service can be more definitely anticipated in the final restoration of dental function because of thorough understanding and complete cooperation through all the phases of treatment which this splendid teamwork assures. Not the thought of special interests or divided responsibilities but rather the combined energies and devoted interest of the entire personnel are assurances of the most favorable results and outstanding achievements.

## LECTURE VIII

### GUNSHOT WOUNDS OF THE FACE

**T**HIS paper will take up surgical principles rather than specific or technical details and procedures connected with wounds of the face. Since ancient times the trend in the treatment of wounds has swung back and forth from curative to prophylactic measures. The cauterization therapy dominant in surgery during the early part of the 16th century was discarded as the result of a chance experience of the eminent Pare on the battlefield. Accustomed to the use of boiling oil, he was forced on one occasion by an accidental exhaustion of the supply to omit its use, and was surprised to find that the wounds healed more readily and without the usual sloughing and inflammation. Thanks to this discovery, surgeons were led to discard the former drastic measures and to place greater reliance upon the inherent healing properties of the tissues, and for many years thereafter wound management was limited to the gentlest cleaning and the application of the most innocuous substances. The general opinion was expressed by Paracelsus in 1536 when he wrote, "Warily must the surgeon take heed not to remove or interfere with nature's balsam, but protect and defend it in its working and virtue. It is the nature of the flesh to possess in itself an innate balsam which healeth wounds." In the middle of the 19th century Lister's announcement of the bactericidal properties of chemicals swung the trend in favor of "curative" measures based on the use of germicides. The wide experience of the first World War demonstrated the fact that the orthodox treatment of wounds by means of chemicals was ineffective and often harmful. However, from these experiences developed the Carrel-Dakin method of wound treatment.

In 1914 the treatment by "excision and primary suture" was introduced by Gray at Rouen, and Lewis states that "from then on the surgery employed in the treatment of war wounds became preventive rather than curative." Following the first World War many new antiseptic solutions were developed and their virtues extolled, whereupon we returned somewhat to the Listerian era.

Recently the experience of surgeons in the Spanish war has been appearing in the literature and a great deal of prominence has been given to a method of treatment which they used rather extensively, especially for the extremities. This consists of debridement of the wound and packing with vaseline gauze, then the application of a plaster-of-Paris cast. Time will not permit a more detailed discussion of this method, but it is interesting to note that this method has not received universal acclaim. Desjacques and Auger, in an article entitled "Some Reflections on the Wounded of the Spanish War," stated that they had treated at the Hotel Dieu at Lyan, 68 wounded soldiers who had come from Spain and southern France. They deplored the prevalent practice of war surgeons of covering contaminated wounds with dressings and plaster-of-Paris, as the only treatment. They emphasized that the fundamental surgical principles for treatment of wounds should not be forgotten and that immobilization in plaster is only an adjuvant.

Let us consider briefly the tissue changes that take place in healing to get a

clear physiological understanding of what our treatment should and should not do. Wound repair is usually described as (1) healing by first intention, (2) healing by second intention, the fundamental difference being quantitative rather than qualitative. By first intention is understood ideal healing with a minimum of granulation tissue and a minimum of scarring. It occurs when the skin edges have been carefully approximated, the patient's resistance is good and there is a minimum of bacterial invasion, and when the treatment has been adequate. Healing by second intention implies more granulation tissue, and consequently, more visible scar tissue. Immediately following the infliction of the wound there is an extravasation of lymph and fibrin which attempts to glue the cut surfaces together. The blood vessels dilate and the surrounding tissues become infiltrated with inflammatory exudate. The damaged, devitalized cells are either engulfed by leucocytes which migrate into the wound, or are digested by tissue enzymes. In twenty-four to thirty-six hours the endothelial cells of the damaged capillaries proliferate to form vascular buds. These tufts unite with each other and soon tunnel out to form new capillaries which assist in the absorption and solution of the remaining inflammatory exudate. Coincidental with the formation of the capillary loops, fibroplastic cells migrate into the wound and bridge the adjacent surfaces. Simultaneously with these changes in the deeper parts of the wound, the epithelial cells advance from the wound margins toward the center. I have taken time to discuss this phase to show why we should not put strong antiseptics into fresh wounds in an attempt to sterilize them because of the action of these solutions on the healing process, which begins as soon as the wound is incurred. There are many factors which may influence this process, such as the age of the patient, his general state of nutrition, and the amount of bacterial invasion of the wound.

The course of treatment will depend upon the extent of the bacterial invasion. All wounds are contaminated, the bacteria being introduced by the traumatizing agent, by foreign bodies, and at times by the use of unsterile dressings applied as first aid measures. The bacteria thus introduced find the devitalized tissue favorable to their growth and if allowed to become acclimated they multiply and overcome the natural resistance of the tissue fluids and invade the surrounding tissues, converting a contaminated wound into an infected one. As long as the wound is merely contaminated, it is possible to secure adequate asepsis by means of soap and water and gentle cleansing alone or in combination with excision of the devitalized tissue or debridement. It is generally admitted that mechanical cleansing and surgical excision of the wound followed by primary suture is an ideal procedure; however, its use is limited to wounds which are not so large and deep that excision would endanger important structures such as blood vessels and nerves. This is particularly true about the face where a definite economy must be exercised to conserve tissue, both for cosmetic and functional results.

A general survey of the extent of injury is made and an estimated plan of procedure outlined. This survey should include x-ray films as indicated which will assist in estimating the amount of bony damage and the presence of buried, metallic foreign bodies. If the patient is composed and morphine is

not contraindicated and the wound not extensive, a hypodermic injection of  $\frac{1}{4}$  grain of morphine may be all the anesthetic that is needed. In more extensive wounds other means of anesthesia must be employed, as it facilitates the cleaning of the wound and permits a more thorough approximation of the tissue. We favor the use of local procaine, but the use of an inhalation or an intravenous anesthesia may be necessary. However, they have their limitations for use about the face and air passages. For those who are needle shy, a pack of gauze saturated with 5% procaine and left in the wound five minutes will frequently give sufficient anesthesia. If the wound has been covered by a first aid dressing this is removed and a fresh sterile dressing is applied to the wound, and the skin adjacent to the wound is thoroughly cleaned and prepared with soap and water. Dried blood may be removed with swabs saturated in hydrogen peroxide, and if grease is present benzene or ether will assist in its removal. All surrounding hair should be shaved well back from the wound edges and the skin prepared with any good skin antiseptic, such as alcohol, iodine, merthiolate, metaphen, or alcoholic mercurochrome, and then draped with sterile linen. If local anesthetic is to be used, it is now instilled well back of the traumatized area. The wound is thoroughly washed out with soap and water with cotton sponges, with frequent flushing of clean sterile saline or distilled water. All foreign material such as blood clots, dirt, splinters, shell fragments, pieces of cloth, et cetera, are carefully and thoroughly removed. In wounds about the face, debridement should be carried out with discretion. Tissues normally exposed to bacteria—namely, skin and mucous membrane—are highly resistant to bacterial invasion and may therefore be excised sparingly. Surgical cleansing is begun in the deepest part of the wound and carried toward the surface, all detached and hopelessly damaged tissue being removed. Bone splinters still attached by means of periosteum, unless grossly comminuted, should be thoroughly cleaned and replaced. Hematoma should be evacuated. Subcutaneous fat, if soiled, is trimmed away, care being taken, however, not to remove so much of it as to cause an interference with the blood supply of the overlying skin. The amount of skin or mucous membrane to be sacrificed will depend upon its blood supply and upon the degree of crushing as indicated by the amount of bleeding from the cut edges. In any case, as previously stated, it should be trimmed sparingly. Even when the blood supply is doubtful, an attempt should always be made to preserve every scrap of tissue, however slenderly attached, for although later some of it may be lost, ultimately there will be a greater saving than if all the damaged skin had been removed at the outset. The bruised edges are cut away in straight lines in order to create a smooth, even surface for approximation, since irregular margins, even when they heal by first intention, leave noticeable scars. In hemostasis the vessels should be clamped and blind grasping of masses of tissue avoided. Further trauma to the wound should not occur from reparative technique, and a minimum of suture material, foreign body, should be left in the wound. Throughout the entire procedure frequent flushings of the wound with warm sterile saline solution is recommended. The use of powdered sulfanilamide in these wounds is also recommended prior to closure, especially if bony injury has been incurred, but we do not feel that its use should be a

routine measure. If cleansing of the wound has been efficient and thorough, and the injury but recently incurred, with gross contamination at a minimum, its use should not be necessary. The surgeon should not slight these other measures and then be lulled into a sense of false security because he has placed sulfanilamide in the wound.

We believe that each patient, regardless of status, is entitled to as careful suturing of fresh wounds about the face as is possible, consistent however with the general condition of the patient. What good will a very careful suture job on the face be if the patient dies?

I recall two cases very well. At Walter Reed recently a cashier from one of the leading hotels was brought in. He had been cut through the chin down the side of the neck, exposing the trachea. The length of the incision was eight inches. We did a primary suture, which was taking somewhat of a chance, perhaps. However, it was a clean incised wound, comparatively speaking, and the man did get primary union. In Hawaii I had an interesting case. A Filipino was standing by the side of the road repairing a tire. He straightened up suddenly, and the handle of the door caught him in the mouth and ripped his cheek back from the mandible.

Some two and a half to three hours of painstaking suturing were required in each case. However, the cosmetic and functional result, the gratitude of the patients, and the personal satisfaction well repaid for the time taken. Facial surgery demands somewhat different treatment than that administered to wounds of the extremities. According to Straith, a thorough wound cleansing and hemostasis is essential, drainage should be provided for deeper wounds, and heavy sutures, needles, skin clips and the like are to be avoided. The edges of each wound should be meticulously straightened and sutured with fine material such as horsehair in a manner which will bring the edges of the wound into precise union. Sub-cuticular sutures produce the most ideal results. The elasticity of horsehair makes it an excellent material for subcuticular suturing. In the last year a nylon suture has been developed which has about the same elasticity as horsehair and which we have used with satisfaction. The use of a magnifying lens may at times be an aid in securing accurate apposition of skin edges. In the fresh facial injury very little advantage can be taken of Langer's lines of the skin about the face, but when practicable these elastic lines kept parallel with them as much as possible. Lines of sutures should never be placed at right angles to these lines if this can be avoided.

It has been stated that the period of contamination lasts between 6 to 8 hours. However, owing to the varying character of wounds and the different circumstances causing them, as well as the varying amounts of gross contamination, this period has a wide latitude. Once invasion of the surrounding tissues has taken place and the bacteria have penetrated into the tissue, cleaning and removal of the devitalized tissue is all that can be done, as excision would then entail the sacrifice of great masses of tissue and the opening up of new avenues for spread of the infection. Treatment should be aimed at intensifying the natural defenses and a delayed primary or secondary closure. If the time interval between injury and institution of treatment has been prolonged and the wound is infected or definitely suppurative, our plan of treat-

ment must be modified. Cultures should be taken and the predominant organism determined. Our plan of treatment should aim to assist nature by (1) ridding the wound of purulent exudate and necrotic tissue, (2) limiting bacterial growth, and (3) intensifying the defensive reaction of the tissues.

In cleaning up an infected wound of the purulent exudate and limiting bacterial growth, we have used all the accepted procedures, but have been most impressed by the use of azo-chloramide solution, with a detergent as an irrigating agent, followed by the use of azo in triacetin. In our cases of infected wounds, x-ray therapy has been found to be a definite benefit in localizing the infective process and hastening the decrease of inflammatory reaction. The surgical dictum of adequate drainage must be maintained, and a means established for the evacuation of pus as rapidly as it forms. To intensify the defensive reaction of the tissues, rest to the part and the application of warm wet dressings, and one of the sulfanamide drugs, by mouth if possible, or by subcutaneous route, are advised. Rest is important in the healing of any injured tissue. About the face, this is of extreme importance. What have come to be known as the dangerous areas of the face are those in which the veins about the nose and lips lead to the cavernous sinus within the cranium, are lacking in valves, and have relatively rigid walls. The stage is set, as to the anatomy, for rapid spread of infection and catastrophe. Eating, drinking, laughing, smiling, since they produce changes in facial expressions and are therefore motions, activate the process of dispersion. When infection in these areas is found, the first concern is to assure immobility, by whatever means it can be secured, and the less that is done locally the better. Trauma is a major danger. Heat increases the blood flow, promotes leucocytic moisture, prevents crusting, promotes leucocytic activity, and raises the metabolism, while moisture prevents crusting, promotes drainage, and relieves pain. Various methods for the application of warm wet dressings have been described, and each surgeon has found by experience a method which gives him the best results. We use as a routine wet dressing several layers of gauze loosely over the part, with one or two catheters over these with the large end outside the dressing, then a pad made of cotton between a layer of gauze, and the whole dressing encased in oiled silk and secured with a roller bandage. The oiled silk helps to maintain the heat and moisture in the dressing and also aids in keeping the bed clothes about the patient dry. We use a solution of glycerine and 70% alcohol, half and half, instilled into the dressing through the catheter with a syringe after it has been warmed. The amount instilled and the frequency of instillation will depend upon the size of the dressing, but should be of sufficient amount and at sufficient intervals to maintain a constant, even, moist heat in the dressing. Auxiliary heat may be used, if desired, by means of a heat cradle or hot water bottles, or properly insulated electric heating pads. Many solutions, if used over a period of time in a wet dressing, will cause maceration of the skin. In the more severely injured, the general supportive measures must not be neglected, especially if the convalescence is prolonged. Rest in bed, maintenance of fluid intake, adequate elimination, and an easily assimilable nutritious diet favor a satisfactory convalescence. In cases of severe loss of tissue and bony injury requiring prosthetic appliances to maintain position, it

may be necessary to insert a Levine nasal-gastric tube for feeding or the supplemental use of intravenous infusions. Needless to say, there should be the closest cooperation between the dental surgeon and the surgeon, if the patient is to receive the maximum of benefit from the treatments.

Sometimes in medicine and surgery we become so interested in the treatment of a certain condition that we forget all about the patient. We treat the disease and not the patient, which is a rank fallacy. The patient's life is naturally the first consideration. I will mention shock only to reemphasize its importance in conservation of life in the severely injured. Hemorrhage and shock are closely allied. However, I would like to bring out certain points in regard to the control of hemorrhage in wounds of the face. The method to be adopted will depend on the location and extent of the hemorrhage and the facilities available, and may even have to be at the expense of asepsis. When the bleeding is profuse, pressure with sterile gauze may be sufficient; if, however, the bleeding vessels can be caught with a sterile hemostat, it is much better. Pressure can also be exerted against some resistance over the proximal limb of the bleeding vessel and the hemorrhage controlled until other measures can be instituted. Bleeding from the common carotid, vertebral, and inferior thyroid arteries can be controlled by exerting pressure against the transverse process of the sixth cervical vertebra; from the subclavian by pressure against the first rib in the space between the clavicle and sternomastoid muscle; from the facial by pressure against the mandible at a point immediately in front of the masseter muscle; from the temporal by pressure against the zygoma just in front of the ear.

In injuries about the face, examination must determine whether the patient has sufficient airway through the pharynx, and that blood and secretions do not accumulate in the throat and choke him. If the patient is conscious his cough reflex will assist him in keeping the larynx free, but if he is unconscious the person taking care of him must assume this responsibility. The use of morphine should be carefully considered before it is given. It is contraindicated if there is any suspicion of an intracranial injury, and its effect on respiration must be kept in mind. Recently the universal immunization with a tetanus toxoid has been adopted, and more recently an intranasal method of immunization against tetanus as a means of creating a state of anti-toxic immunity in advance of an injury, with a tetanus-toxoid topagen. Gold, reporting in the *American Journal of Surgery*, states that active immunization can be maintained in advance of an injury by the repeated use of tetanus-toxoid topagen intranasally. A course of three daily instillations should be repeated every six months following the initial immunization.

## LECTURE IX

### GUNSHOT CASUALTIES AND SHOCK

THE onset of World War I provided great impetus to the study of shock. Casualties were dying in large numbers because of the lack of knowledge concerning the treatment of shock. Physiologists and surgeons devoted time and energies to the study of shock and its many manifestations. As a result of their investigations, general interest in the prevention and treatment of "wound shock" was aroused. The observations made in France in 1917-1918 on the methods of treating shock made a profound impression on military as well as civilian surgical practice and many of the principles developed then are in use today.

Following the World War, many outstanding contributions to the literature on shock were presented in the reports of Cannon, Blalock, Parsons and Phemister. Cannon contented that shock was produced by the absorption of toxic materials from the site of injury, and this belief has been propounded as the Toxemia Theory of Shock. Many investigators supported this contention until the publication in 1930 by Blalock and a short time later by Parsons and Phemister of their classical experiments from which they concluded that shock was produced by loss of fluid locally at the site of injury. They contended that the volume of blood lost into the injured area and surrounding tissue was sufficient to reduce the circulating blood volume to such an extent that shock ensued. Their experiments also provided strong negative evidence that the absorption of toxins from the injured area played no part in the production of shock.

#### PRESENT DAY CONCEPT OF SHOCK

A clear conception of the alterations in physiology that occur in the syndrome of shock is necessary for an understanding of this subject. There are several facts pertaining to this syndrome, labeled peripheral circulatory failure by Blalock, that are universally accepted as being true. It has been shown conclusively that shock is not due to inefficiency of the heart nor to the interference with the nervous mechanism controlling its function. It can easily be shown that if the heart is supplied with a sufficient blood volume, it will continue to function efficiently even though the animal is in profound shock. Experimental work of investigators has revealed that there is a marked decrease in the amount of circulating blood in the vascular system in shock. Whether shock is produced by trauma or hemorrhage, this fact remains an outstanding feature in the clinical picture. What happens to the lost blood has provoked a considerable amount of comment. It is generally accepted that the lost volume can be accounted for by the stasis of the blood in the peripheral capillaries and by transudation of the plasma into the tissues. Moon is of the opinion that the larger portion of the lost blood can be found in the visceral areas and serous cavities. The fact remains that there is a definite fluid loss which is considered to be the most important single factor, if not the initiating factor, in the production of the clinical picture seen in shock. There is a

reduction in the volume flow of the blood in shock. This means that there is a decrease in the amount of blood reaching a given portion of tissue in a unit of time with a resulting oxygen depletion. There is also a decrease in cardiac output caused by a deficient venous return.

That hemoconcentration occurs in shock is well known. With the resulting increase in viscosity there is an additional slowing in the rate of blood flow. The determination of the concentration of the blood provides an excellent criterion as to the degree of shock that may be present. It is well established that the vasomotor center remains active in shock, and the theory that shock is caused by vasomotor exhaustion is not tenable. With these facts at hand, the definition of shock as given by Moon is clearly understood. He has defined shock as "a circulatory deficiency, not cardiac nor vasomotor in origin, characterized by a decreased blood volume, decreased cardiac output (reduced volume flow) and by increased concentration of the blood."

Blalock has classified shock into four types: neurogenic, hematogenic, vaso-genic, and cardiogenic. In gunshot casualties and shock we are primarily interested in the first two. The neurogenic type of shock is characterized by acute circulatory failure or syncope and is frequently referred to as primary shock. This type is rapid in onset following trauma, fear, surgical procedures, et cetera, and is characterized by vasodilatation, warm extremities, normal or slowed pulse and a drop in blood pressure, but no loss in circulating blood volume. Owing to the reflex inhibition, with vasodilatation, there develops a discrepancy between the circulating blood volume and the volume capacity of the vascular tree. The disturbance of physiology seen in primary shock is amenable in its early stages to vasoconstrictor drugs and the administration of fluids.

The hematogenic type of shock corresponds to the so-called secondary or delayed shock. It usually develops several hours after injury, but may be a continuation of neurogenic shock. As a result of trauma; plasma, and possibly whole blood, pass from the circulation through the capillary walls into the tissues in and around the injured part. Loss of plasma results in a decrease in the venous return to the heart. To compensate for this loss of fluid locally at the site of injury, there is a generalized peripheral vasoconstriction which serves to maintain a physiologic blood pressure and also helps to provide an adequate blood supply to the brain and other vital organs. This prolonged peripheral vasoconstriction causes capillary stasis and a further decrease in the venous return to the heart. Owing to the loss of fluid and diminished return flow of blood to the heart, there is a decrease in cardiac output. The lowered output of blood, plus the stasis in the capillaries, serves to reduce the volume flow of blood per unit of time. Eventually this generalized vasoconstriction causes an oxygen depletion in the peripheral tissues, and, as the oxygen debt mounts, it becomes more difficult to repay. In addition, the capillary endothelium, because of anoxia, becomes more permeable and there is a generalized loss of plasma. When this state has been reached, decompensation occurs because of the gross discrepancy between fluid volume and volume capacity of the vascular system. When the blood pressure remains low for a considerable length of time, the oxygen want increases, and generalized peripheral

vasodilatation results. At this stage there are many factors in conjunction with the low blood pressure and decreased oxygen supply which militate against the recovery of the patient. These may be listed as low alkali reserve, decreased heat production, vascular stasis, and the lowered vitality of the tissues, resulting from a long-standing oxygen deficit. This series of disturbances in physiology usually develops over a period of several hours. Once the blood pressure has fallen and remained low for a few hours, the process is irreversible, and no known treatment will prevent the inevitable result—death.

Therefore, it may be said, briefly, that the present concept of shock is based on the premise that there is either a decrease in the circulating blood volume or a discrepancy between the blood volume and the volume capacity of the vascular system, or a combination of the two. The alteration of the normal physiologic processes initiated by the above changes results in tissue anoxia and death.

#### PREVENTION AND TREATMENT OF SHOCK IN COMBAT

Forty years ago Crile stated that "the best cure for shock is prevention." Frazier, in 1935, in a paper on the treatment of surgical shock, wrote an appropriate admonition which should be borne in mind: "Begin the treatment of shock before its onset." These observations are true today. The advances made in the prevention of shock have greatly outdistanced those that have been made in treatment.

##### 1. The General Condition of the Soldier.

A person who is well fed, wearing warm clothes, and in other respects normal will withstand trauma much better than a person who is in poor physical condition. In combat, as a result of prolonged exposure, short rations, lack of water, poor heating, constant nervous strain, and depletion of reserve strength from marching and fighting, the average combat soldier has a very low threshold of resistance to trauma and to the development of infection. This must be considered of primary importance in the prevention of shock. Every effort should be made to restore these deficiencies and prevent them when possible. It is essential that each man receive at least two quarts of fluid per day. Food should be of proper composition and adequate in amount, providing a large amount of proteins and essential vitamins. Evidence has accumulated that Vitamin C is especially important in wound healing. Warm, dry clothes should be provided when available.

##### 2. Control of Hemorrhage.

It is the duty of every Medical Department man to understand the methods of controlling bleeding. When the casualty is first seen by the company aid men or personnel of the battalion aid station, steps should be taken to prevent bleeding. Simple methods should be used. Bleeding wounds should be covered with a tight dressing and the part elevated. If this is ineffective, the wound should be packed with sterile gauze and pressure applied over the artery supplying the area. If large bleeding points are visible, they should be ligated. It should be emphasized that only sterile gauze or bandages should be used and that the use of chemical antiseptics in the wound should be prohibited. Not until all other methods have failed should a tourniquet be resorted to.

After the tourniquet is applied, a check at frequent intervals must be made to prevent the results of prolonged restriction. If allowed to remain in place for over an hour, stasis of blood with developing tissue anoxia results and when the constrictor is removed, the increasing permeability of the capillaries allows additional loss of fluid into the tissues. This hastens the onset of shock and the tissues become boggy and resist infection poorly.

### 3. Splinting.

Complete immobilization of fractured bones is the goal sought in applying splints. This goal is rarely attained in the combat zone. Although immobilization is not complete with the means at hand, the patient is made more comfortable and the reduction and after treatment is simplified upon being evacuated to the medical installations in the rear of the combat zone. When proper splints are used the possibility of compounding is minimized and soft tissue damage is reduced. These points stress the need for adequate splinting as a preventive measure in shock.

### 4. Heat.

A very important factor in combating shock is the prevention of exposure to cold, with resulting loss of body heat, and supplying heat to the patient after exposure has occurred. Hot drinks in the form of tea, coffee, or cocoa should be given as soon as possible, wet leather and clothing should be removed, and the patient should be placed on a shock bed or litter properly prepared. Blankets for this purpose are available at the battalion aid station, the supply being maintained continuously by the litter bearers from the collecting station. Boothby has offered a very acceptable explanation for the necessity of maintaining body heat at normal levels. In severely injured cases, tissue anoxia develops rapidly, and it is extremely desirable that the oxygen supply be kept at the highest possible level. Boothby has shown that a fall of body temperature of 5 degrees Fahrenheit causes a demonstrable reduction in the dissociation curve of oxygen. Increasing the body temperature raises the dissociation curve of oxygen which, in turn, increases the oxygen tension in the tissues. Elevation of temperature will frequently double the rate of circulation which further increases the oxygen tension in the tissues. The methods of supplying heat to casualties in the combat zone are limited. When large numbers of casualties are to be treated, even the best methods available in the field are impracticable. Evacuation must be speeded up with every possible effort made to maintain warmth for the casualties in the ambulances.

### 5. Drugs.

The use of vasoconstrictor drugs in the treatment of shock has called forth much comment. Many drugs have been suggested, such as adrenalin, pitressin, strychnine, paredrinol, and others. In primary shock, where one is confronted by a fall in blood pressure, due to vasodilatation without loss of fluid, these drugs may be of value in conjunction with intravenous fluids in restoring the blood pressure to a normal level. However, in hematogenic shock resulting from a decrease in circulating blood volume, restoration of the normal blood pressure is not the main factor sought unless the elevated blood pressure increases the volume flow. In delayed shock there is a generalized vasoconstriction present, the continuation of which is distinctly harmful to the

organism unless blood or plasma is added to make up for the lost blood volume. In view of these statements, it appears that vasoconstrictor drugs are not only of no value in the treatment, but are definitely contraindicated in hematogenic shock.

#### 6. Position.

Lowering the head and raising the feet of patients in syncope, fainting and shock is a procedure of long standing in conditions of this type. The shock position was used routinely in the last war. It has been demonstrated that placing an etherized animal in the "shock position" increases the flow of blood in the carotid artery 30 per cent above that when the animal is horizontal. Due to this increase, the oxygen tension in the cerebral tissues is raised and the mental condition of the patient improves. Inasmuch as no harm is done and good results may be produced by lowering the head, it is felt that the use of the "shock position" should be continued.

#### 7. Pain.

Every reasonable effort should be made to reduce the pain associated with injuries. Dressings should be applied carefully to prevent frequent changes, and they should be applied tightly to prevent slipping and irritation. Fractures should be handled gently and splints fixed correctly to reduce pressure points and prevent movement of the fragments. Morphine is indicated in doses of  $\frac{1}{4}$  to  $\frac{1}{2}$  grain. The use of large doses of morphine in seriously injured patients is considered unsafe, and it may add to an already existent oxygen deficiency. The use of morphine is contraindicated in head injuries.

#### 8. Barbiturates in Shock.

Experiments have proved that the effects of trauma are withstood longer under sodium amytal and pentobarbital sodium than when the patient is anesthetized with ether. It was found that when the latter was given several hours after trauma was produced, the drug was effective in slowing the detrimental alterations in physiology that occur in the production of the syndrome of shock. It appears that shock develops more slowly under pentobarbital sodium anesthesia than when ether is used. These findings should not convey the impression that pentobarbital sodium should be used as a prophylactic measure in the treatment of the injured, but rather that this drug is indicated as a supportive agent if the injured are to be given an anesthetic.

#### 9. Replacement of the Lost Fluid.

As indicated in the discussion on the physiology of shock, the decrease in circulating blood volume is the most outstanding single factor in the production of shock. It follows that the replacement of the lost fluid is by far the most important form of therapy known to prevent shock. Early replacement is essential. Many types of fluid have been tried as blood substitutes.

During the World War saline and glucose were used subcutaneously, per rectum, and intravenously. The results in the seriously wounded were poor. Saline, being a crystalloid material, is not retained in the circulation for any length of time, and the elevation of blood pressure following its administration is only temporary. When given several hours after injury, it is distinctly harmful, as it not only is lost from the circulation but also apparently carries some of the protein molecules from the blood stream into the tissues with it. The

decrease of osmotic pressure in the vascular system, resulting from the use of saline, is considered detrimental.

Acacia 6 percent solution in .9 percent saline was also used during the last war. It provides a colloidal solution with about the same viscosity as blood and is capable of sustaining osmotic pressure, even though inert itself. Evidence has accumulated to show that acacia may interfere with gaseous exchange and cause conglutination of red cells resulting in capillary blockage. It is, therefore, advisable to use acacia only when blood and other blood substitutes are not available.

The development of the "blood bank" in this country has increased the use of blood transfusions tremendously. In civilian hospitals this method of supplying blood has proved very satisfactory. The use of this plan in the Army, especially in the forward areas, has many limitations and is impracticable. These limitations do not prevent the use of whole blood in evacuation hospitals and general hospitals. In these installations both direct and indirect transfusions can be accomplished without interference.

The quest for an adequate substitute for whole blood has perplexed clinicians and investigators for many years. The use of crystalloids, colloids, cadaver blood, and placental blood have met with varying success. During the past three years much work has been done on the use of serum and plasma as blood substitutes. As the result of a great deal of experimental work, it has been suggested that "lyophilized" plasma should be used for the treatment of traumatic shock. The results of these studies are very encouraging and it appears that a satisfactory substitute for blood has been found. The question may be raised, are we providing adequate replacement of the lost fluid in shock, hemorrhage, and burns when plasma is used? When the alterations in physiology are considered, it becomes clear that we are.

In shock the outstanding change that occurs is the loss of plasma from the circulation. The red blood cells are retained. Therefore, there is a hemoconcentration, increased viscosity of the blood, and stasis. Plasma replacement is the obvious treatment and is probably more desirable than whole blood. In hemorrhage, the loss of red blood cells is not so important as the plasma reduction. Patients will tolerate a tremendous decrease in red cells if the plasma volume is retained. Thus, plasma infusions are indicated as good treatment for hemorrhage. In burns, the loss of serum and plasma, producing hemoconcentration also calls for plasma infusions.

It should be stated that serum and plasma differ in composition, methods of collection, and in the effects resulting from administration. Serum is the liquid portion of blood that separates when blood clots. Plasma is the supernatant fluid collected from blood when an anticoagulant is added and the blood is centrifuged to remove the red corpuscles. Strumia has reported reactions from the use of blood serum, but has given plasma as much as five times concentrated without reactions occurring. He suggests the explanation that reactions caused by serum are probably due to the process of fibrin precipitation when serum is separated from the clotting blood. When plasma is collected 500 cc. of blood yield about 260 cc. of plasma. The yield of serum from an equal quantity of blood is only 180 cc. For the reasons enumerated

above, it may be that plasma is the better and safer of the two to use. For our purposes in warfare, plasma is infinitely superior to blood. The reasons are that it can be used without typing after the iso-agglutinins are suppressed by pooling plasma from different donors; it can be safely stored for approximately one month at room temperature and for many months at 4 degrees centigrade (six months); it can be transported without alteration; it is ready for instant use and can be injected fairly rapidly; it does not increase the concentration of red corpuscles when injected.

The previous remarks have been confined to liquid plasma. The most important contribution to the use of fluids in warfare has emerged from the development of machines for drying biologicals. The advantages of dried plasma apparently outweigh all other substitutes for blood that we now have. It can be preserved almost indefinitely—at least three years. The bulk of liquid plasma is somewhat reduced by the drying and the weight is reduced by virtue of the fluid volume being removed. Dried plasma is easily regenerated by the addition of distilled water to the powder. It can be safely given in four times concentrated amounts and it does not have to be warmed prior to injection. Thus we have an agent of tremendous military surgical importance. That plasma should be used for replacing the diminished blood volume in shock is generally admitted. That it can be made available in large quantities by voluntary donors is highly probable. The available plasma can be dried and stored for an indefinite period; it can be transported easily, reactivated and supplied to the medical installations with comparative ease; its administration requires but a few minutes to carry out, and, in turn, provides us with a life saving measure.

Knowing that the prevention of shock should start as soon as possible after an injury has been incurred, it becomes apparent that plasma should be given as early as possible to reduce the high mortality rate that results from shock. Having given the necessary first aid and emergency care to the casualties, the intravenous injection of 50 to 100 cc. of two or four times concentrated plasma is a most urgent requirement. Following the injection of plasma, the patient can be wrapped in blankets and placed in a heated ambulance and speedily evacuated. By following out these procedures the onset of shock will be prevented or certainly delayed until additional fluids can be provided.

#### 10. Oxygen.

Owing to the decrease in circulating blood volume, diminution in cardiac output, and stasis, there occurs an oxygen debt in the tissues which increases as shock develops. It is this mounting tissue anoxia that eventually produces the irreversible stage of shock. To prevent this condition from occurring, Haldane has advocated the continuous administration of oxygen. Boothby and Lovelace have recommended the administration of 100 per cent oxygen as an adjunct in the treatment of shock. They feel the necessity for starting treatment early to prevent the severe damage of tissues which results from prolonged anoxia. It has been shown by these workers that the inhalation of 100 percent oxygen will increase the oxygen content of the blood 10 percent to 15 percent. This will increase the oxygen tension in the tissues and help

prevent the oxygen debt from mounting. A method of administering high concentration of oxygen has been developed by Boothby, Lovelace and Bulbulian. The B-L-B mask is made to fit the face smoothly, making it possible to wear the mask for many hours with only short periods of interruption.

### 11. Anesthesia.

It is the opinion of Blalock that the four anesthetics best suited for use in war-time surgery are ether, spinal anesthesia, intravenous anesthesia (making use of the short-acting barbiturates), and local anesthesia. Ether is the safest anesthesia given by inhalation. Given carefully with oxygen, when necessary, it provides probably the most desirable inhalation anesthesia for major surgery in the combat area. The administration of pentobarbital sodium prior to ether anesthesia will be effective in delaying the onset of shock. The use of short-acting barbiturates, such as pentothal sodium, intravenously, for general anesthesia, should provide an excellent agent for minor surgery, the removal of painful dressings, et cetera. When given by the intermittent method of Lundy, its use is not contraindicated in shock. The use of this anesthesia can be rendered safer by the addition of oxygen inhalations. Local infiltration and block anesthesia with nupercaine offers an ideal anesthesia for patients in shock. The reduction of some fractures is carried out especially well under local anesthesia. The four anesthetic agents enumerated are easy to obtain, they are not bulky to package and transport, and they are fairly simple to administer.

One of the most frequent and dangerous problems confronting medical personnel in the combat zone is shock. The prompt and intelligent management of shock in its earliest manifestations is of vital importance in many of the injuries of the head and neck. Shock suffered by the casualty on the battle-field differs from that seen in civil life in that it is aggravated by fear, exposure, and frequently by a long period of pain without relief. The determined effort of medical personnel in the combat zone should be directed to the prevention of shock before its onset.

## LECTURE X

### CHEMOTHERAPY AND GUNSHOT WOUNDS

ONE of the most discouraging complications of gunshot wounds is infection. It can always be anticipated that a battle wound will be an infected wound. The long period of hospitalization, the stages of treatment, and the patient and continual care required before the reparative surgical plans can be undertaken, are usually due to the serious infective nature of the wounds.

Infection was a serious handicap in the care of battle casualties in the World War. Experimental studies and diligent research were directed to the problems of wound infection and their control. The Carrel-Dakin treatment was the encouraging result of some of these studies and greatly influenced the treatment of battle wounds during the last period of the World War.

With the recent years have come many developments in medicine, and none of them has been more encouraging than the advances in chemotherapy. So important are the developments and so far-reaching in military medicine, that a distinguished group of physicians, working under the auspices of the National Research Council, have studied the possibilities of this new development of chemotherapy in infectious diseases and wound infections to assist the Medical Department in its plans for national defense. These spectacular advances have brought new methods into the field of military surgery and greatly alter and improve our plans to control infection in battle casualties. As a result, we can anticipate a great change in the septic stage through which the wounded have usually passed in previous wars. These great advances have come through the development and use of the sulfanilamide compounds.

Sulfanilamide, known chemically as para-aminobenzenesulfonamide, was first synthesized over 30 years ago by Gelmo. It is a white, practically odorless, slightly bitter, crystalline substance. The spectacular results secured by the use of the sulfonamide group of drugs in the treatment of hemolytic streptococcal and staphylococcal infections, as well as several other serious infections, have been experienced by hospitals throughout the country during the last few years. It is in connection with hemolytic streptococcal and staphylococcal infections in jaw casualties that we are particularly interested.

The compound inhibits bacterial growth. Concentration of 10 mg. percent sulfanilamide exerts a bacteriostatic effect. It produces little or no harmful effects on the phagocytic cells of the host and is readily diffusible through the tissues of the body. Since these chemotherapeutic agents are bacteriostatic, the defensive cells of the host can defeat the infection. Clinically, the effectiveness of the drug appears to be governed by the situation of the infecting organism. If the bacteria are in a poor medium, as urine or blood, the drugs are very effective; if in a good medium, e.g., pus or débris, the drugs have very little effect.

The effectiveness of sulfanilamide in the treatment of some types of infections, as well as its limited influence under other conditions, leads us to assume that it should be even more effective in preventing infection. It appears the

effectiveness of the drug is dependent upon its early administration and high concentration. In the treatment of battle casualties, it is important that it be administered as soon as possible after wounding. The drug should be given by mouth and implanted locally in the wound. The initial dose by mouth should be 6.0 grams. This should be followed with a dose of 1.0 gram every four hours day and night until the temperature is normal. After apparent clinical cure, 0.5 gram should be given every four hours until the patient has received the drug for a total of ten days.

The use of sulfanilamide by local application in the wound is of particular interest in the treatment of jaw casualties. When the crystalline sulfanilamide is insufflated in the wound, it is dissolved in the serum and other fluids, and the local tissues become saturated. This high concentration is contained by the local tissues for some hours, but eventually is taken up by the blood. Sulfanilamide can dissolve to the extent of 0.8 percent. Therefore the local concentration might readily approach 800 mg. per 100 cc. A concentration of 10 mg. percent sulfanilamide exerts a significant bacteriostatic effect, and it is reasonable to suppose this higher level would be bactericidal for the organisms within the wound. This is particularly valuable in our approach to the problems of gunshot wounds and compound fractures of the jaws. Experiments carried out in compound fractures in which the wound was contaminated with a virulent strain of *Staphylococcus aureus hemolyticus* indicated that the healing processes were much better in the cases given the drug systemically. Key and Burford carried out a series of experiments to determine the influence of the local implantation of sulfanilamide in a compound fracture. They concluded that the local implantation of the drug not only lessened the danger of infection, but did not interfere perceptibly with the union of the soft tissues or the bone.

Following these experiments, a series of clinical reports brought convincing evidence of a sound clinical routine for the treatment of compound fractures in the early control and prevention of infection. It is evident that the usual surgical toilet of wounds must be demanded in the procedures. Painstaking cleansing of the wound, removal of all débris, and meticulous care of the injured tissues, followed by irrigation are fundamental requirements. Crystalline sulfanilamide (5 to 15 gm.) is insufflated into the wound, which is then closed without tension by interrupted sutures. Key and Burford have reported excellent results, but insist upon debridement. The special care which must be given to wounds of the face demands extreme care in debridement. Removal of foreign material and the careful removal of devitalized tissue is, of course, essential, but extreme care must be exercised in this operative procedure lest the loss of tissue limit the possibility of subsequent plastic repair. In the large open wounds, which cannot be closed because of extensive loss of soft tissue, the wound should be cleaned, devitalized tissue removed, and the wound surface sprinkled with sulfanilamide crystals. The wound is then covered with a thick layer of vaseline gauze.

As in previous experiences with gunshot wounds of the jaws, immobilization is an important factor in the prevention of infection. The use of chemotherapeutic agents as an adjunct in the treatment of jaw casualties in the combat zone may reduce the incidence of wound infection tremendously. Sulfa-

thiazole has proved most successful in combating streptococcus hemolyticus and staphylococcus aureus infections. In diffuse staphylococcal cellulitis, lymphangitis, or acute osteomyelitis the initial dose of sulfathiazole should be 4.0 gm. followed by 1.5 gm. every four hours day and night as long as the infection spreads. When the advance has been brought under control, the dose should be reduced to 1.0 gm. every four hours night and day and continued as indicated.

No chemotherapeutic drugs are completely innocuous. Small doses are usually tolerated well; in the administration of larger doses certain toxic symptoms may appear. Bigler and Haralambie recognize several toxic reactions from sulfanilamide as allergic, mild toxic, and severe toxic symptoms. Allergic symptoms are itching of the skin with urticaria; edema of the face; sneezing, lacrimation and dyspnea. The mild symptoms are nausea, vomiting, abdominal pain, diarrhea, increased urination, anorexia, weakness, dizziness, fever, acidosis, and cyanosis. These disappear with the withdrawal of the drug. Severe toxic symptoms include shock, jaundice, anemia, leukopenia, agranulocytosis, neuritis, and psychosis.

It is to be recommended, when possible, that laboratory control of bacterial chemotherapy be carried out, but inability to do blood and urine examinations should never be considered a contraindication to the use of these drugs. If facilities are available, hemoglobin determinations should be done every other day during the first week of treatment, and once a week thereafter. Total and differential white blood cell counts should be done every other day for the first 7 days, and (particularly important) if the patient continues treatment with sulfanilamide or its derivatives, every 2 days between the 14th and 40th days. Urine examinations should be done on alternate days in patients who are receiving sulfapyridine or sulfathiazole. The urine should be examined macroscopically for blood. The volume output of urine in patients being treated with sulfathiazole or sulfapyridine for serious infections should be recorded daily. Patients receiving sulfonamide compounds should be seen at least once a day and should be questioned as to the presence of headache or malaise. These are frequently important early symptoms of toxic reactions. Patients should be inspected at each visit for the presence of jaundiced sclerae (acute hemolytic anemia or hepatitis), pale mucous membranes (acute hemolytic anemia) or rash. The temperature should be recorded. *With recurrent fever after normal temperature in the course of sulfonamide therapy, the drug should be discontinued immediately or if recently discontinued, should not be resumed unless it has been demonstrated that the fever is due to a recurrence of the infection.* Whenever therapy with the sulfonamide drugs is stopped because of a drug reaction, *fluids should be forced to 5,000 cc. per day in order to wash out the drug.*

Agranulocytosis is extremely rare before the 14th day of therapy. It is imperative that total and differential white blood cell counts be made in patients still under treatment after the 14th day, every 2 days from the 14th to the 40th day. If the polymorphonuclear leukocytes fall to 50 percent or less in adult patients, stop the drug immediately. Granulocytopenia without agranulocytosis may occur.

Any patient who has had a toxic reaction to one of the sulfonamide group of drugs may have a second and more severe toxic reaction if one of these drugs is prescribed again. In such individuals a small test dose of the drug (0.1 to 0.3 grams) should be given, the patient observed for 12 hours before intensive therapy is started, following which the patient must be carefully observed and the drug immediately stopped on the first appearance of any toxic manifestation.

The splendid efforts made by the Committee on Chemotherapeutic and other Agents of the Division of Medical Sciences, National Research Council, to assist the Medical Department of the Army will influence the treatment of gunshot wounds in our efforts to prevent infection. Their work will greatly influence the development of newer methods in the care of jaw casualties. A more satisfactory and expeditious routine in the treatment, elimination of the many weeks of the septic stage, and more favorable bone repair for jaw casualties can be anticipated.

## LECTURE XI

### JAW WOUNDS AND INFECTED BONE

**C**OMPLICATED inflammatory conditions are encountered in practically all gunshot wounds of the jaws. While the infection of the soft tissues will be most apparent, these same factors contribute to the infection of the injured bone. The jaw casualties usually present comminution of the bone, broken teeth, and destruction of the soft tissue. If the foreign matter penetrates the tissues, inflammation of the injured bone almost always develops. This results in an acute osteitis which later develops into osteomyelitis. The severe pain within the bone fragments indicates a developing osteitis. Pus is present and frequently discharges spontaneously around the teeth. The tissue is red, tender and swollen. There is severe pain; chills and fever, and headaches follow. Early recognition and attention to these symptoms, and treatment, are essential. Prolonged suppuration through the mouth wound or the external wound indicates the presence of an osteomyelitic focus within the bone fragment. The x-ray will not disclose bony change at this stage, for such changes are microscopic in character at this time. The clinical symptoms warn of impending complications, requiring early and constant therapeutic measures to limit the progress of the pyogenic infection. In many of the jaw casualties, the conditions are most favorable for infection of the bony fragments. Comminution of the bone, especially with shattering of the teeth and severe injury to the soft tissues, almost always results in a certain degree of osteitis and subsequent osteomyelitis.

In the early stages of osteomyelitis, x-ray examination reveals but little. Later, the characteristic blurring of the fine bony structure may be recognized. With the progress of the infection, devitalization of the bone segment occurs with the formation of a sequestrum. The separation of the sequestrum eventually occurs. Conservatism is imperative in all cases of osteomyelitis, but it is of the utmost importance in gunshot jaw casualties. No radical measures should be resorted to. Curettage or removal of bone is contraindicated, for it will spread the infection and frequently interferes with ultimate bone repair. Drainage is important, and effective measures should be taken by incision of the periosteum. This is usually the only operative interference indicated in the early stages. As the sequestrum forms and loosens, it should be removed, gently.

Several serious conditions common to a majority of gunshot wounds of the jaws influence the progress of osteomyelitis. Impaired blood supply is usually a factor. The nature of the wound, diminished blood supply caused by injury to the blood vessels, inhibits the activity of the osteoclasts and osteoblasts, and bone regeneration does not take place. It is well to note that over 90% of the gunshot wounds of the jaws result in compound fractures and develop abscesses and necrotic conditions involving bone. Under these conditions, we cannot expect the normal repair of the bony structures in gunshot wounds of the jaws. It has been definitely established that bone repair or regeneration may be of a physiological or pathological type. In jaw injuries in which the damaging influ-

ence of infection and injured blood supply impair normal reparative processes, pathological regeneration takes place, and complete anatomical replacement never takes place.

We must also consider the special difficulty in the presence of comminuted bone. Close examination of a wound will always disclose particles of comminuted bone with periosteal attachment. Even though the wound is infected, these small portions of viable osseous tissue should not be removed. They may later become centers of osseous regeneration, or nature may exfoliate them, and they can be removed when near the surface of the wound. Comminuted fractures, even when compound, unite with surprising firmness and rapidity under favorable treatment.

A majority of gunshot wounds of the jaws present serious infection. In war we must be prepared to anticipate infection. Upon the removal of a dressing after forty-eight hours, we may expect to find free flowing pus, necrotic tissue, and serious and dangerous complications. There will be a septic stage through which the patients must pass before the infection is cleared up and reparative processes can regenerate new bone.

The newer types of therapy will greatly change present-day experience from that of World War days. In no field of surgical repair will more encouraging results be anticipated than in the field of maxillofacial surgery. Even with the remarkable developments of chemotherapy, the oral surgeon must exercise every precaution to eliminate infection and encourage bony repair. During this stage, immobilization of the bone segments is absolutely necessary. Early fixation of loose segments, except in cases where sequestration follows later, is of prime importance in the early control of infection.

Any presentation of the problems of bone infection in connection with jaw casualties calls for a discussion of bone repair if we establish the most desirable methods for the final restoration of the jaw structures.

The process of tissue repair is most complex, and studies regarding bone repair disclose some very interesting phenomena. Studies of the biology of bone have established the fact that bone and cartilage are derivatives by adaptation from connective tissue. Under certain conditions, bone will revert to connective tissue or cartilage will be transformed directly into bone. In fact, tissue of the connective tissue group undergoes ready and frequent transformation. One must bear in mind the connective tissue origin of bone and that it dominates all the problems of its growth, regeneration, and repair. While bone repair takes place, reproducing its own structure, there are striking differences between physiological regeneration, which is a result of tissue stimulation, and pathological regeneration, or the reparative changes in the tissue following infection or injury. In physiological regeneration, the used and lost tissue substance is constantly replaced in a typical way; in the pathological regeneration a complete anatomical replacement is never attained, even if an attempt is made to replace functionally the lost or damaged tissue. This is observed in the tissue changes incident to orthodontic treatment as compared with the changes resulting in the regeneration following osteomyelitis.

These basic principles are observed in all healing processes which are the result of injury or trauma to bone. The end results may approach normal bone

in form and structure or the results may disclose bone more or less abnormal in form but capable of good function. The regeneration attained is directly dependent upon the extent of injury to the blood-vessel connective-tissue apparatus through the damaging influence of the processes following injury or infection.

The normal reparative process in an ordinary simple aseptic fracture is the result of a small number of simple agencies. (Fig. 34.)

1. Post-traumatic hemorrhage between the fragments and the periosteum.
2. Organization of the clot and rarefaction of the ends of the fragments.
3. Formation of new bone in the clot organized in the periosteum.
4. Union of the fragments by callus.

The hemorrhage is followed by the coagulation and formation of the blood clot. The congestion in the bone produces resorption with the liberation of calcium salts. Under normal conditions it follows that the callus will form as an inevitable phenomenon. When we consider the immediate consequences resulting from the traumatism present in jaw casualties with biologic events

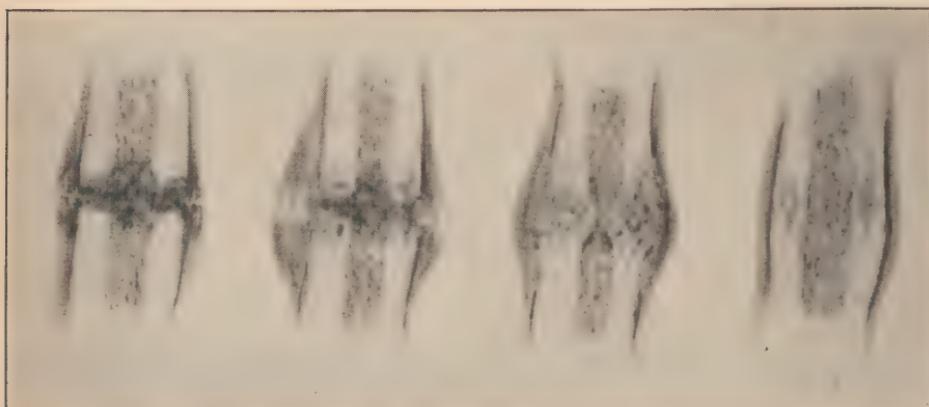


Figure 34.

incident to bone repair, some of the complex factors involved become apparent. It is evident that the periosteum plays a most important role in bone regeneration.

Repair is possible only so long as the circulation leading to the tissue in question is intact. Even in jaw casualties with extensive loss of bone, the regenerative power of the periosteum is so great that its thorough destruction would be necessary to prevent bone formation. Only through the early proliferation of non-specific connective tissue or the destruction of the blood supply is regeneration of the periosteum destroyed.

Bone regenerative processes are closely associated with an undamaged blood supply to the osteoblasts and with the fracture hyperemia at the seat of the lesion, occurring immediately and continuing undisturbed for a sufficient period. If the vascular supply is damaged primarily or interrupted during the course of the regenerative process, bone regeneration does not take place. These dam-

aged parts, particularly under the influence of undesirable stimuli, are prone to degenerate. Damaging the blood supply usually leads to pseudarthrosis.

While there are several factors which might result in non-union, the consideration of the abnormal changes in the process of bone regeneration are important in the examination of tissue transformation in bone repair. The usual changes show that the callus constitutes an actual union of the fragments. Normally there follows an increase in the density and solidity of the callus. Several factors enter into the orderly transformation of this fibro-connective tissue callus. Ossification is one of these late changes in the callus which results in firm and dense union of the fragments. It is not the only change that may take place.

Disturbing factors, frequently met in gunshot casualties, may disturb the normal evolutionary tissue changes. Indifferent reduction of the fragments, improper fixation, unreduced fragments, or mechanical stimuli with damaged blood supply, may so alter the normal process of bone repair that the callus undergoes a fibrous change, resulting in pseudarthrosis. The undisturbed re-

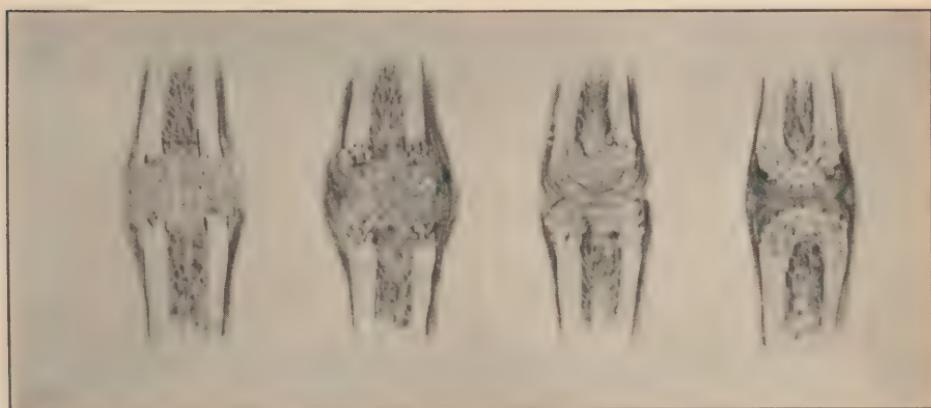


Figure 35.

parative mechanism may be compared with the normal process of repair. (Fig. 35.)

1. Post-traumatic hemorrhage between the poorly adapted fragments.
2. Rarefaction of the fragments and connective tissue organization of the blood clot.
3. Formation of new bone toward the fragment ends with fibrous transformation of the callus.
4. Arrest of repair, and resultant pseudarthrosis.

These striking changes so alter the reparative process that regeneration cannot take place. The callus does not form and interfragmentary ossification is impossible.

Further examination of the problem of non-union and pseudoarthrosis disclose some very important factors in the treatment of jaw casualties. The interposition of muscle tissue—even a small amount—prevents union. Con-

stituting an obstacle which the process of ossification cannot surmount, it is impossible for such tissue to become ossified.

Infection at the site of fracture may result in pseudarthrosis. The sclerotic change in the connective tissue becomes a mechanical obstacle which reparative processes cannot overcome. A slight infection will present congestion and infiltration of the periosteum favoring the formation of a large callus. The union of the fragments will be abnormal and the new bone formed will be lacking in density and with a structure of an inferior quality. An intense infection at the site of fracture is followed by tissue necrosis, prolonged suppuration, and a distinct alteration in the metaplastic changes which prevent regular and sufficient ossification.

The suppuration following infection in jaw casualties also influences the calcific changes. Frequently it prevents calcification by directing this mechanism away, or by altering the calcareous material. Infection also interrupts ossification so that bony deposit is only spotty and irregular.

It follows that, in cases of gunshot wounds of the jaws, the disturbances encountered in the process of bone repair are common. Added difficulties develop through the influence of the foreign bodies, bits of clothing, teeth, fillings, et cetera, which are within the wounds. The formation of thick fibrous tissue and dense sclerosis of the callus increases the complications and discourages the essential factors necessary for regeneration.

A large number of jaw casualties are seriously complicated through infection of the fragments. Many of these cases come under such general classifications as unreduced fractures, non-union, loose fibrous union, et cetera. All of these cases will present a history of bone infection. The principles so frequently mentioned throughout many of these lectures are exceedingly important in the elimination of infection and the promotion of bone repair. Early treatment must demonstrate a sound application of these principles if one is to avoid prolonged infection. The newer knowledge of chemotherapy will limit the infections so common in jaw casualties, while early and accurate fixation will eliminate the mechanical irritation which disturbs regeneration. Conservation of tissue and blood supply, as well as the surgical cleansing of the wounds, are important in the prevention of suppuration.

Infected bone presents one of the most troublesome complications of jaw wounds. The recognition of the problems, the understanding of the most advanced methods of treatment, proper steps for the elimination of infection, and sound decisions in planning treatment will control many of the complications and assure the most desirable end results.

## LECTURE XII

### FRACTURES OF MAXILLA AND MANDIBLE

WHILE the usual consideration of maxillary fractures is concerned with the various types encountered in civil practice, in military dentistry we must consider the unusual and great variety of types associated with gunshot wounds. In war the injuries are usually very destructive, and frequently examination discloses extensive comminution and loss of bone. Occasionally only a contusion of the soft tissues may be present, but examination will disclose a break in the bone with little or no comminution, simulating the

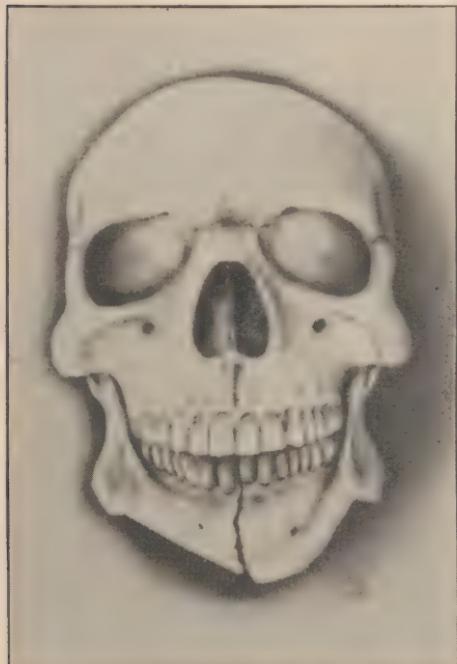


Figure 36.

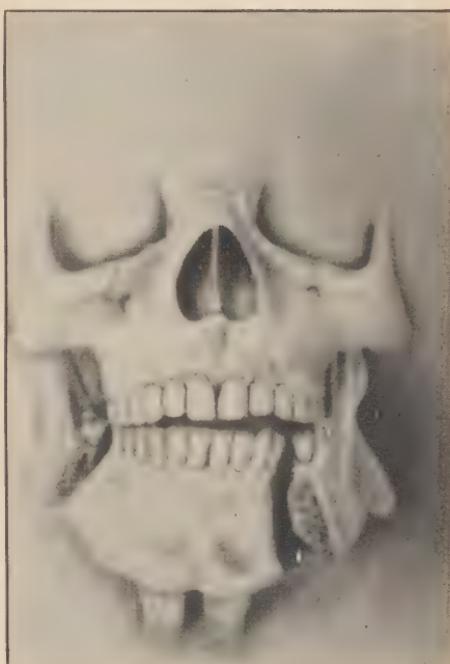


Figure 37.

fracture common in civil practice. For these reasons a more comprehensive study of maxillary fractures is necessary.

#### FRACTURES OF THE MANDIBLE

Since destruction of both hard and soft tissues is common in gunshot wounds of the jaws, we must anticipate severe displacement as well. Of course, the degree of displacement in fractures of the mandible depends upon the direction and force of the traumatizing force, the amount of comminution, the presence or absence of opposing teeth, and the action of the muscles attached to the fragments. Fractures in different locations present characteristic displacements.

Where there is considerable comminution or loss of substance of the symphysis with loss of teeth, the lateral fragments of the mandible tend to be drawn together at the median line by the contraction of the mylohyoid muscles. This causes a marked narrowing of the lower arch. (Fig. 36.)

A fracture in the region of the mental foramen or body of the mandible presents certain characteristics. With a good complement of teeth in both upper and lower jaws, the short fragment posterior to the fracture is elevated and held by the teeth in original occlusion with those of the upper arch by contraction of the elevator muscles (temporal, masseter, and internal pterygoid). The large fragment is depressed by the muscles passing from its lower border to the hyoid bone (diagastric, geniohyoid, mylohyoid), so that the anterior teeth do not occlude with those of the upper jaw. (Fig. 37.) In severe

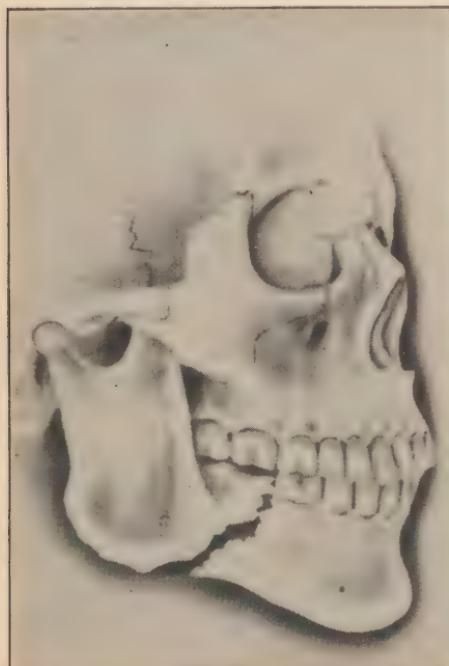


Figure 38.



Figure 39.

cases of comminution there may also be some backward displacement and lateral deviation of the chin segment to the side of the fracture with overlapping of the fragments. When teeth are missing from the short posterior fragment, the elevator muscles accentuate the upward displacement of this edentulous fragment. (Fig. 38.) This displacement of the short posterior fragment may also be outward or inward.

If a fracture of the ascending ramus is presented with little or no comminution, displacement may be very slight, owing to the investiture of the fragments by thick muscles. Where comminution or loss of substance does exist, shortening will occur with deviation of the chin toward the fractured side.

Fractures of the neck of the condyle are nearly always due to indirect force, such as a fall or blow on the opposite side of the chin. Occasionally the condyle is displaced forward and inward out of the mandibular fossa by the external pterygoid muscle. (Fig. 39.) Frequently the condyle may not be displaced, but the lower end of the small fragment may be tilted forward and inward. (Fig. 40.) However, there is always a shortening of the distance from the angle of the mandible to the mandibular fossa on that side. When the patient tries to open the mouth, the distance between the maxillary and mandibular teeth on that side is less than on the normal side. (Fig. 41.) The whole mandible drifts toward the injured side. Bilateral fractures through the necks of both condyles are sometimes seen. In this type the lower jaw as a whole is displaced backward.



Figure 40.



Figure 41.

In bilateral fracture of the body of the mandible the chin segment is drawn downward and backward by the hyoid group of muscles, the posterior fragments being held up by the elevator muscles. This collapse of the middle fragment, especially in cases of comminution, may allow the tongue and soft tissues to fall back and interfere with respiration and swallowing.

In fractures of the maxilla, owing to the absence of powerful muscle attachments, displacement of the fragments is not due to muscle pull but to the direction of the traumatizing force and to gravity.

Unilateral fracture of the maxilla is usually caused by direct force from the front or from one side. The entire maxilla on the affected side sags and may

be forced inward with overlapping of the palatine suture. (Fig. 42.) Occasionally the fragment will be forced outward, causing separation at the mid-palatine suture.

Bilateral horizontal fracture is usually caused by direct force from the front, such as the face striking the framework of a suddenly arrested automobile or airplane. (Figs. 43 and 44.) The force carries the entire maxilla somewhere above the level of the palate backward, and gravity causes it to sag down posteriorly. The upper and lower posterior teeth may be brought together, while there is an open bite in front, with the upper anterior teeth well back of the corresponding lower teeth.

As a result of a gunshot wound or very severe trauma from below, the fragile

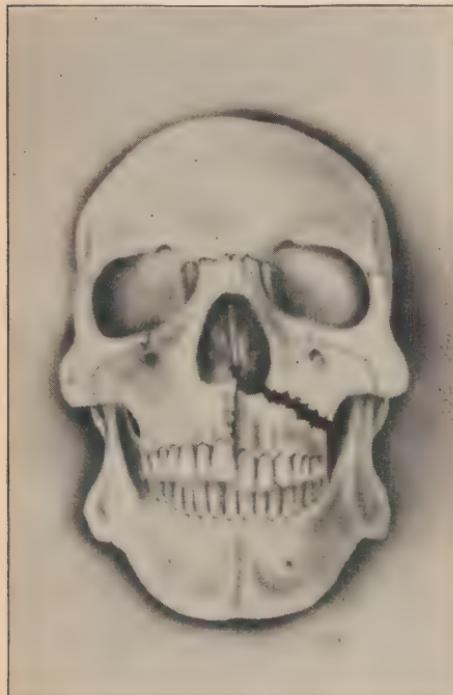


Figure 42.

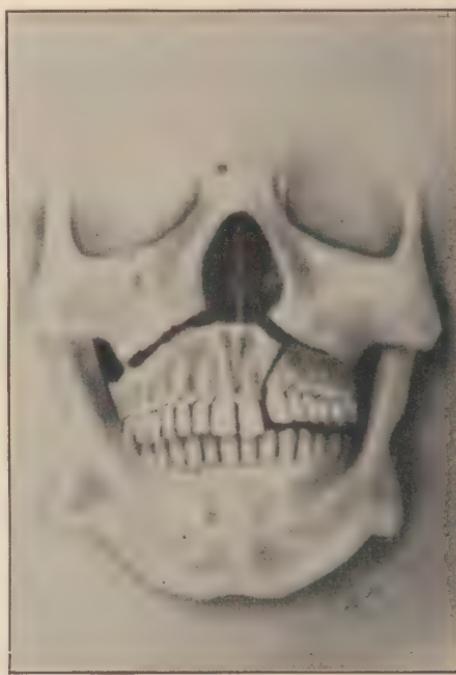


Figure 43.

bones attaching the main body of the maxilla to the base of the skull may be crushed or destroyed, leaving the maxilla freely movable and held only by the soft tissues. (Fig. 45.) It is in fractures of the maxilla particularly that involvement of the nasal fossa, the sinuses, the orbits, the intracranial complications are so frequently seen.

#### TREATMENT OF JAW FRACTURES

Two previous lectures have been devoted to the first aid and emergency care of gunshot wounds of the jaws with the various complications accompanying such cases. It is our purpose to discuss and illustrate the most acceptable

modern treatment developed for traumatic injuries of the face and jaws with resultant maxillary fractures. The methods described have been adopted as the uniform or standard plans for the treatment of maxillary fractures in the Army.

The dental oral surgeon must always give thoughtful consideration to several factors in the early care of maxillary fractures. The initial consideration, when the case is examined at the hospital, should always be relative to the extent of the injury. Today, a large number of face and jaw injuries are due to traffic accidents. These cases usually disclose the patient has been thrown with great force or has been struck in the face by some powerful object. For this reason, many times the more serious injuries are at the base of the skull. Such injuries are extremely serious and demand frequent consultation with the head

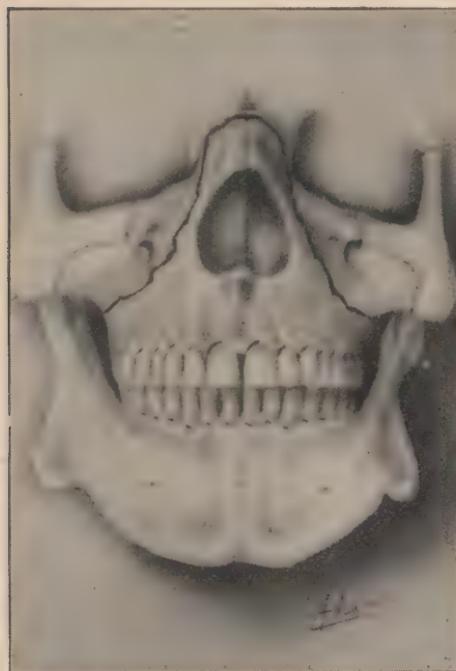


Figure 44.

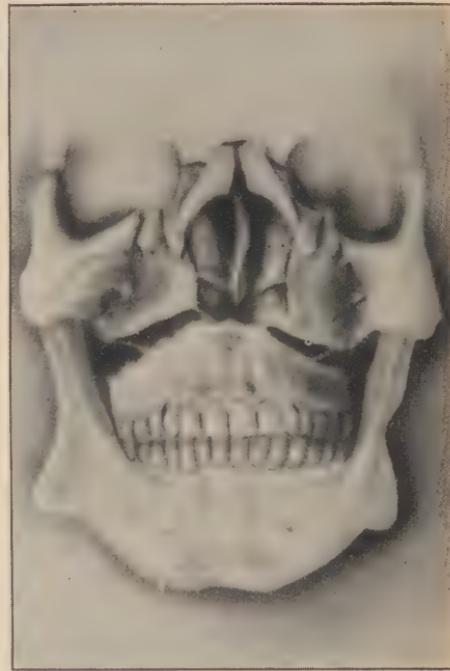


Figure 45.

surgeon before any steps are taken to reduce maxillary fractures. Evidence of concussion and other signs of brain or cord injury lead one to exercise great caution and keen judgment before undertaking correction of the maxillary difficulties. Injuries to the upper portions of the face frequently involve the eyes; depressed fractures may include the nose and floor of the orbits. (Fig. 46.) In all these cases, the dental surgeon must work with specialists in these associated fields to assure the most favorable results. The clearing of the airway, removal of bone particles which might be aspirated, control of hemorrhage, and removal of troublesome blood clots will suffice for a few hours until the extent and seriousness of the injury can be ascertained.

Training in the care of jaw casualties in the battle zone must include instruction relative to bandages. These same principles can be applied and are occasionally necessary in the early care of maxillary fractures in camp or hospital. The condition of the patient may demand delay, in the judgment of the dental surgeon. Facilities at hand may be so limited, or the injury may be of such a nature, that the patient must be transferred to a general hospital for further treatment. In such instances, bandages should be carefully adjusted.

Bandages are used (1) to support the injured soft tissues and fragments; (2) to control the possible displacement of fragments, particularly any distal displacement; (3) to avoid the collapse of fragments; (4) to assist in the con-



Figure 46.

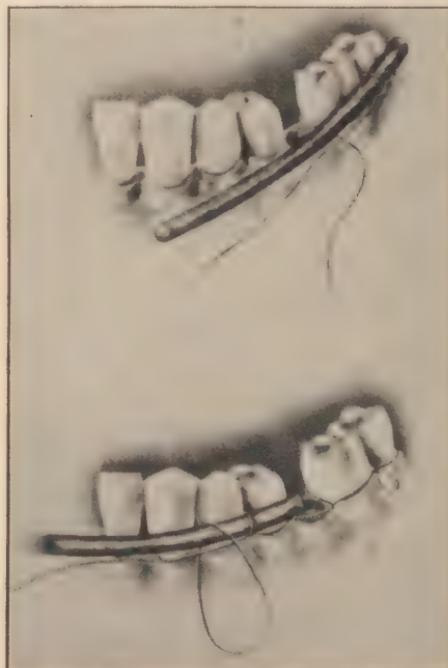


Figure 47.

trol of hemorrhage; (5) to secure control of parts and maintain the airway; (6) to not only control the maxillary structures, but to maintain dressings for injured structures about the neck, eyes, ears, or scalp. Occasionally the bandage to support the maxillary structures can be made in such a way as to maintain large portions of displaced facial tissues.

Bandages for maxillary fractures must always support the fragments in the most favorable position and allay pain. While bandages should be applied with tension over scalp wounds to control hemorrhage, they should be adjusted under the mandible with care to secure immobilization, as a matter of support

to the injured tissues. Occasionally elastic traction is desired as an added corrective support. The Parker bandage is most favorable in many cases, for it gives that added support and limited tension which are most desired by the dental surgeon and most comfortable for the patient. The proper adjustment of suitable bandages will often meet the early demands for treatment until the condition of the patients or the favorable opportunity permits more definite steps in the reduction and fixation of maxillary fractures.

The reduction and retention or fixation of the fragments in the treatment of fractures of the mandible and maxilla require the consideration of several fundamental factors. Owing to the great variety of fractures presented with complications today, many surgical conditions are of far more importance than in the past. Traffic accidents, airplane crack-ups, sports and industrial injuries,

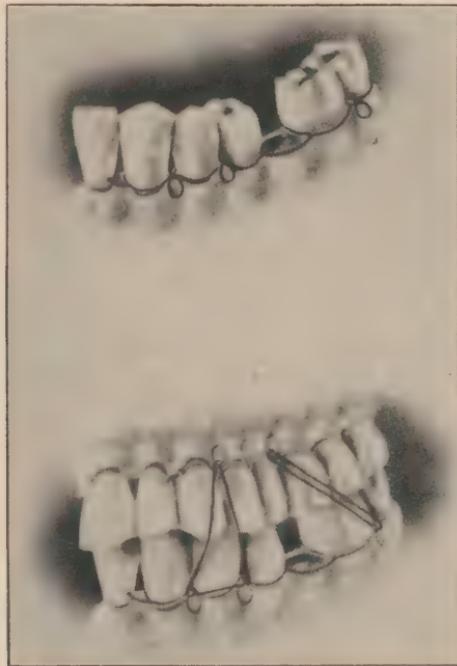


Figure 48.

all are usually situations of tremendous forces and bear upon the conditions presented and the method of treatment. Our efforts must be directed toward restoring the parts to their original condition by obtaining a satisfactory consolidation of the fracture, a result without deformity or disability, and capable of normal function. Other than the surgical aspects, one must use sound judgment in reduction and fixation of the parts, and above all, there must be a sympathetic consideration for the patient's comfort and welfare.

It is apparent that any means of reduction and fixation that permits of early function is most desirable. The bony union is secured much earlier and the normal processes of repair are likewise stimulated under normal condi-

tions. Rubber traction is one of the most satisfactory agencies for the rapid reduction of displaced fragments; its proper application also acts for retention or fixation of the parts. The stability of the appliance is of primary importance. Widely distributed and connected anchorage assures this stability and aids in successful treatment. These various aspects are paramount and their consideration has led to the development of a multiple loop intramaxillary wiring technique and a modification of splint construction.

The dangerous factors of intermaxillary fixed wiring and intermaxillary lock pin splints are for the most part eliminated. The possibility of aspiration and lung involvement is reduced owing to the fact that in most cases there can be limited function and in many cases full function, also better mouth hygiene can be maintained.

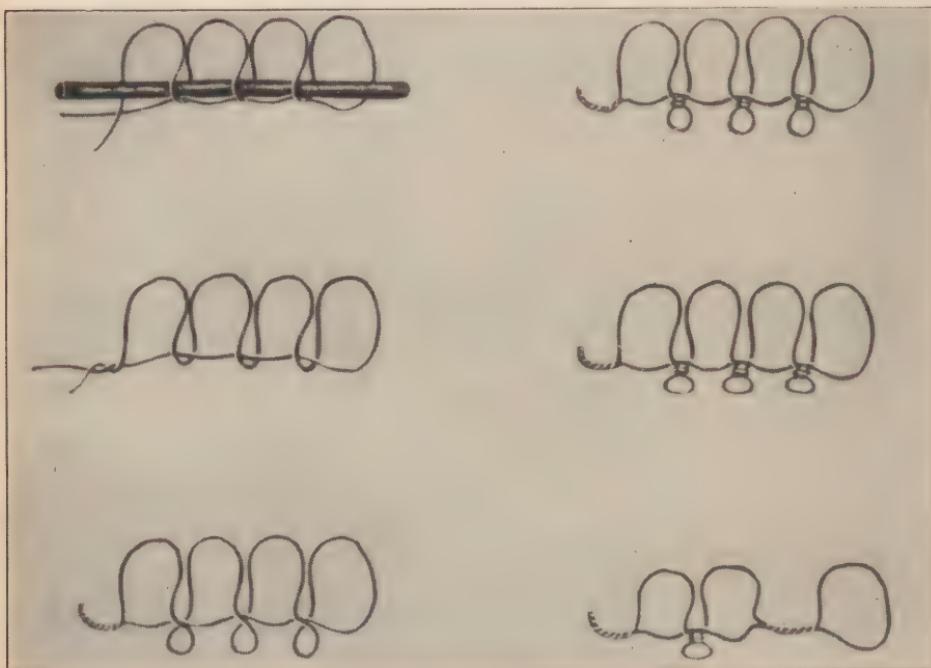


Figure 49.

#### INTRAMAXILLARY MULTIPLE LOOP WIRING

This method for reduction and fixation was developed for two reasons: to secure the maximum anchorage for traction and retention and to apply the required treatment as rapidly as possible. Either Angle's standard brass ligature wire or stainless steel wire, of the proper gauge, may be used. Owing to the greater strength of the latter, a smaller gauge wire may be used.

Using a single wire with multiple loops for a stable and satisfactory fixation, we will consider its application to four teeth, from the first molar to the canine. This will require a wire about nine inches in length sufficient to engage the

four teeth, form three loops, and the necessary length for twisting the two ends together. If more teeth are to be included, a longer wire will be necessary.

The wire is first threaded through the interproximal space between the first and second molars, from the lingual aspect. Pull the wire through buccally and forward, along the buccal surface of the teeth as far forward as the lateral incisor, allowing sufficient length for the final twisting of the ends at the mesiofacial angle of the canine. The long lingual end is threaded through the interproximal space mesial to the first molar, passing gingivally to the wire lying along the buccal surface of the teeth. Bend the long end back on itself, threading it below the buccal wire, through the same interproximal space forming a loop. At this point a lead wire, gauge 8, and about 2 inches long, is inserted in the loop and held parallel with the buccal wire and in contact with

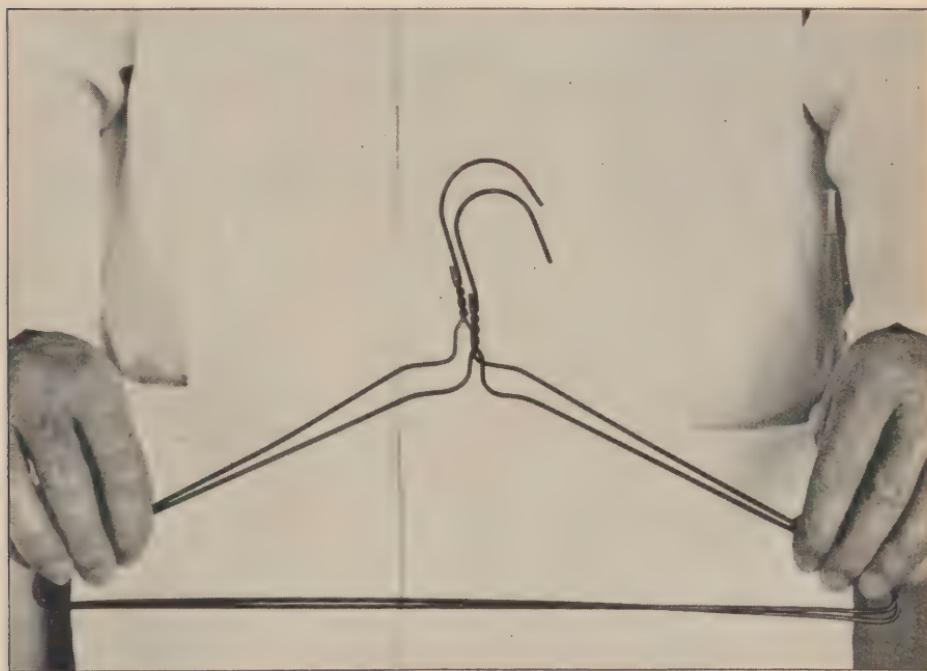


Figure 50.

the buccal aspect of the teeth. (Fig. 47.) The lingual wire is now pulled tightly, giving the loop its proper form and size in correct relation to the buccal wire and the teeth. The lingual wire is then threaded through the next interproximal space (between the bicuspids), passing above the buccal wire and the lead wire, bent around the lead wire and threaded below the buccal wire back through the interproximal space and drawn up tightly once again, thus forming the second loop. In the same manner the next loop is made between the first bicuspid and the canine and the lingual, and drawn tightly so that the lead wire is held rigidly against the buccal surface of the teeth. The lingual wire is now threaded through the interproximal space between the

canine and lateral and again drawn up tightly. Pull forward (mesially) on the buccal wire with the same tension as on the other end. This will draw the loops all up into their proper position and give them the desired uniform size. The lead wire is now removed, rotating slightly and moving forward. This is easily done by grasping the anterior end with pliers or the fingers. The ends are again grasped with the pliers and twisted a few times so as to stabilize the wire and to bring the twisted portion to rest on the mesiofacial angle of the canine. Starting with the posterior loop, grasp with smooth beak pliers (No. 122), and twist  $\frac{3}{4}$  turn which will place the loop in a horizontal position, bringing the buccal wire slightly into the embrasure. Proceed in the same manner with the other loops. This adapts the wire well around each tooth. Start again with the twisted ends and give them the final adjustment, twisting

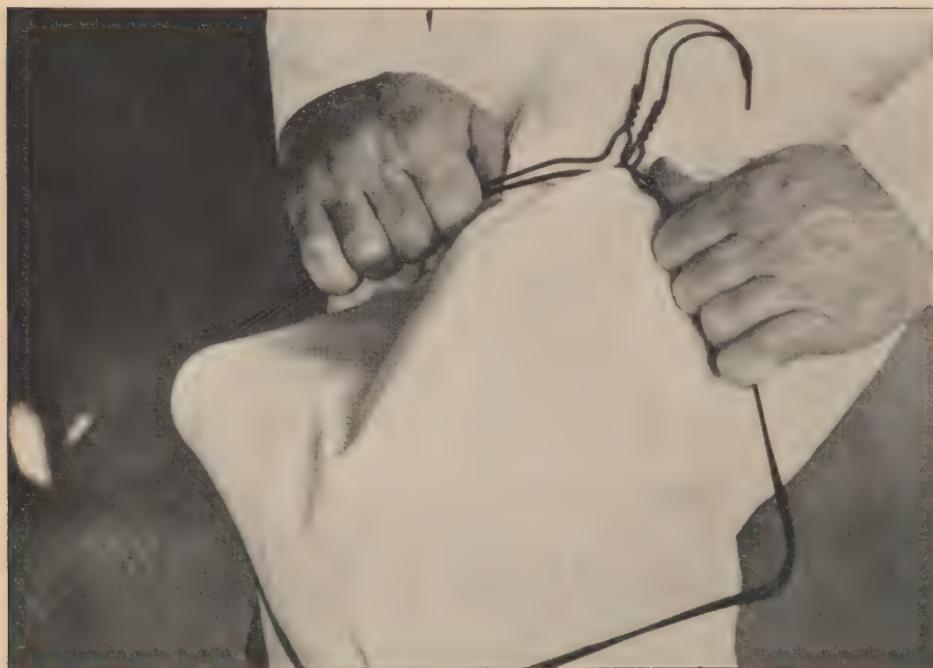


Figure 51.

until it fits the mesiofacial angle snugly. Cut off the excess twisted ends and neatly adapt against the mesial aspect of the tooth and into the embrasure. On occasions this can be carefully adjusted and used as an additional hook. The next adjustment of the loops is accomplished by giving each one an additional half turn which gives the wire the final adjustment around each tooth, carries the buccal wire closer into the embrasure, and secures the loops in their proper positions. The final adjustment of the loops is to bend them gingivally so that they are in light contact with the gingiva and may be used as hooks for rubber traction. (Fig. 48.) Then, by the use of small elastics, both intra-maxillary and intermaxillary traction and fixation can be obtained as desired.

Our requirement of stable anchorage with a broad base involving a number of teeth has been fulfilled. Likewise the application of the wire can be quickly accomplished and the manipulation of the parts reduced to a minimum. (Fig. 49.)

#### SPLINTS

In those cases where maxillary splints are indicated, the two or three section types to be described are recommended. These splints are modifications of a heavier and more extensive sectional vulcanite splint observed in use in a Vienna clinic. It is our opinion also that these sectional type splints are much better when constructed of cast silver. In describing the construction of splints the first requisite is, of course, a good accurate impression. The models are

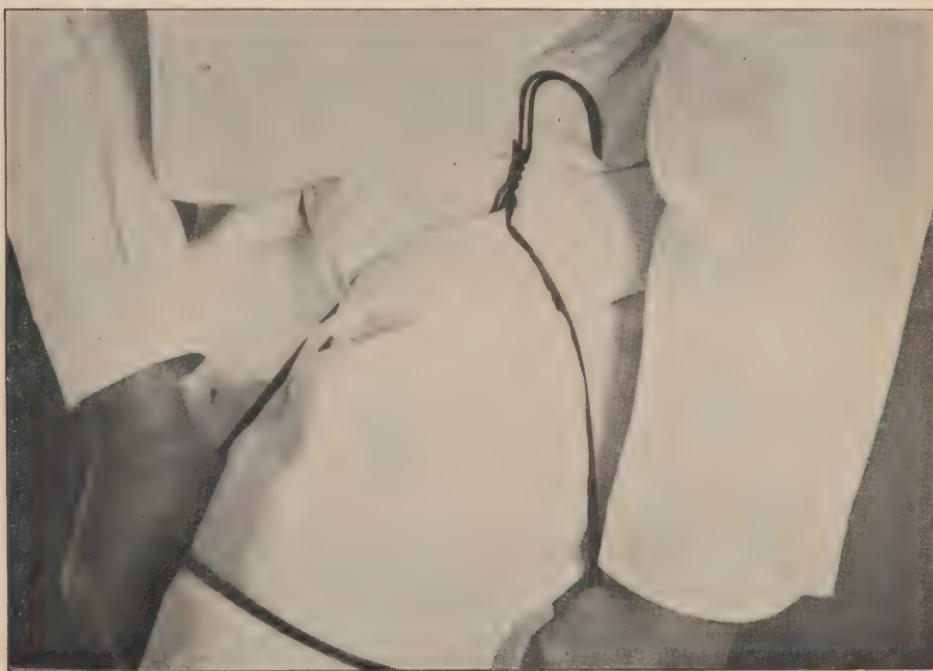


Figure 52.

then poured, and cut or severed through at the lines of fractures to permit the assembling of the parts to restore the original occlusion. These models are retained as master models and duplicates made of stone for vulcanite splints and investment for the cast silver ones. The teeth in the arch to be included in the splint are then waxed from the occlusal third of the crown to two or three millimeters over the marginal gingiva (occlusal surface and incisal edges are not to be covered). When the desired thickness and form have been obtained on both facial and lingual surfaces, the case is ready for hinging or connecting these facial and lingual sections around the posterior teeth included. For this connector or hinge either orthodontia band material or 14

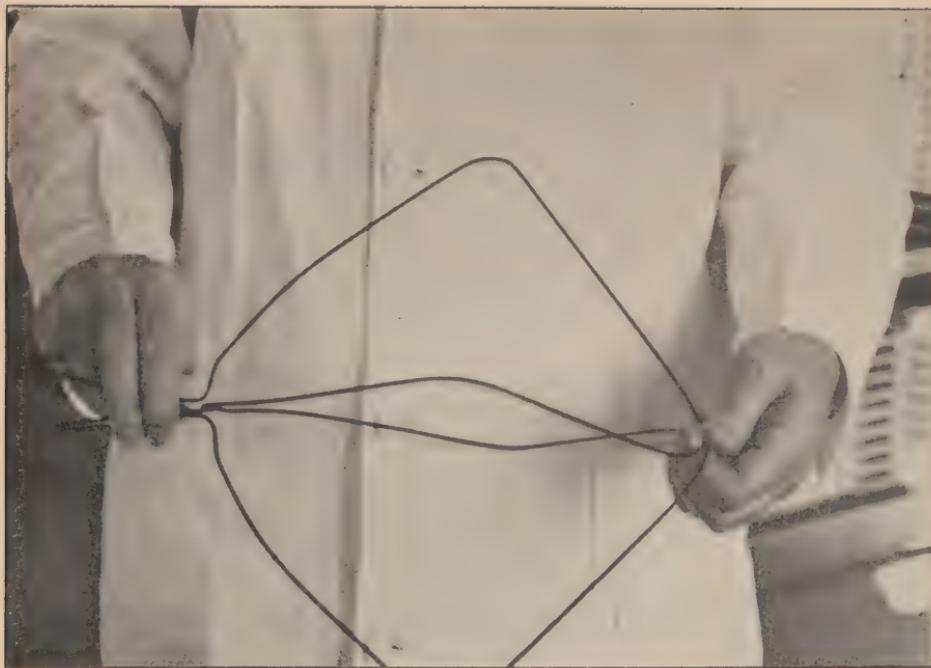


Figure 53.

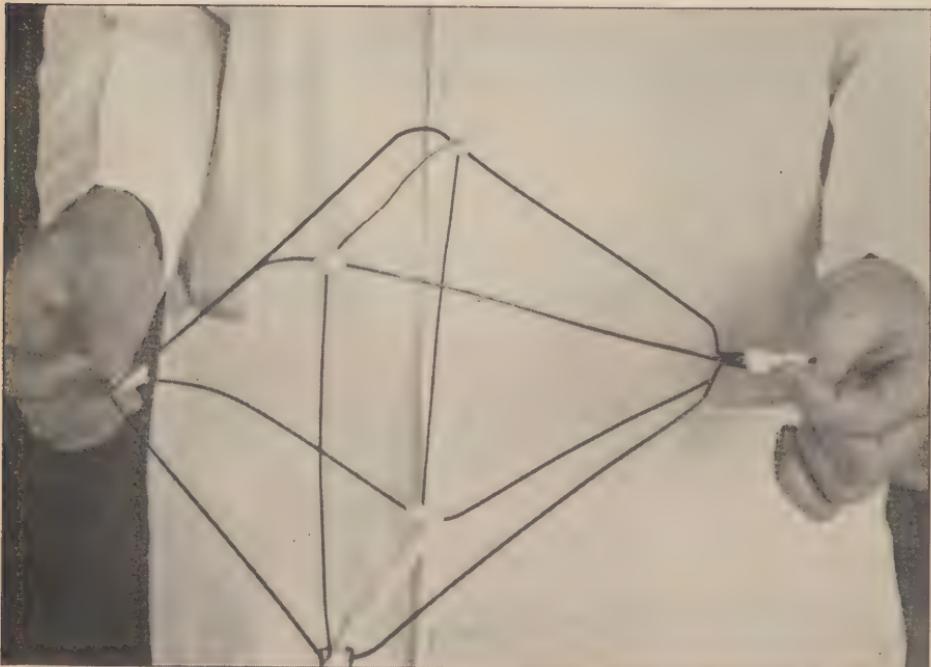


Figure 54.

gauge half round clasp wire has been quite satisfactory. Any other attachments that may be desired can now be added, and also the site for the later cutting of the facial section selected and suitably waxed. It is well to keep in mind that any additions to the splint should be smooth and flat as possible, to avoid any unnecessary bulk or projections which might cause irritation when applied. For that reason undercut button type of elevation makes a desirable attachment for elastic ligatures or wires. When the splint is finally completed and polished, the last thing to do is to saw the facial section through and also saw through any edentulous areas to separate the two facial sections from the lingual section. The splint can now be easily applied to the teeth of the patient and sections firmly closed. The use of cement in setting the splint is optional and dependent on the probable time the appliance will be worn.



Figure 55.

The advantages of a silver splint of this type are many: occlusal surfaces and incisal edges are not covered; there is great strength and firm stabilization without bulk, causing less discomfort to the patient; better hygiene can be maintained more easily. Another great advantage to this splint is that should any tooth included in the appliance become involved, and extraction is indicated, the facial section is simply opened and the tooth removed. The space left in the splint becomes an excellent opening to dress the socket. It should be stated that the silver splints are cast directly to the investment model; therefore they grip the bell of the tooth accurately.

One more point in connection with splints, and that is an extension arm

for reduction and fixation of posterior fragments that tend to be or are displaced upward and laterally. The arm is a square wire projected from a square tube inserted or attached horizontally to the facial section of the splint in that region. The wire is so bent and fashioned that its free end can be placed on the external oblique line of the displaced fragment creating downward and inward pressure. A loop or curve is carried over the ridge of the fragment and back to the facial side before the wire enters the tube, leaving sufficient clearance for the soft tissues of that area. This wire is prepared on the model, and before the appliance is secured to position, a small tissue resection is done over the external oblique line to insure its definite location and lessen chances of irritation and infection at that point. This type of appliance is especially useful in case of an edentulous upper arch. The construction of splints is taken up in detail in Chapter XVI.

In conclusion, when planning the treatment of fractures of the mandible and



Figure 56.

maxilla, the simplest method that can be easily and quickly applied should be considered with the idea of restoration of original occlusion without disability or deformity, and the restoration of normal function.

#### EXTRA-ORAL TRACTION APPLIANCES

This type of an appliance is very useful for early treatment for correction of displacement, particularly in cases of depressed fractures of the maxilla or mandible. It may also be used for the definitive treatment of selected cases.

Again, for the gradual reduction of some depressed fractures with bony union, extra oral traction is essential and the appliance here described has been found of great value.

The wire coat hanger furnishes excellent material of which to construct the frame for the appliance. It permits wide distribution of anchorage; its size affords ample rubber traction with various sized rubber elastics so that one may secure either weak or strong traction. It affords unusual comfort for the patient—a factor too frequently neglected by the dental surgeon. The ease and rapidity of construction afford possibilities for early treatment without the delays encountered when splints or appliances are used which require several hours of laboratory work in their construction. Finally, the use of extra-oral traction for cases requiring this method of reduction permit more rapid reduction or correction of occlusion in a vast variety of cases.



Figure 57.

#### METHODS FOR CONSTRUCTION

Select two wire coat hangers, approximately the same size. (Fig. 50.)

Holding the hangers as shown in the illustration, pull up with the hands and push down with the knee until the wires are bent in such a fashion that they form squares when released. (Fig. 51.)

Holding the coat hangers at the newly formed angles and on the leg, bend the wires over the thigh to approximately a 90 degree angle. (Fig. 52.)

The hangers are now separated and one turned over by holding the ends,

forming a square. (Fig. 53.) The appliance now begins to take shape, for this forms a square wire frame. Tape the ends as they are held together with adhesive tape. (Bandage or small wire may be used.) The angles in the middle of the frame are now connected with an additional coat hanger wire or bandage, using the following measurements: Connect one side, allowing eight inches for the connecting wire; connect the next angle, allowing nine inches for this connector. Extend this wire to the next angle, allowing eight inches for this connector. The frame will now have two sides and the top connected securely. The hooks are cut off the hangers and part of one is shaped into a small hook to fasten the lower connector. This lower connector is made of bandage or tape and should be seven inches long. All connecting wires will have to be moved forward about one inch to increase the head room within the frame. Tape or fasten these connections in proper position, or bend the wire so they will not slip. (Fig. 54.) We now have the frame completed and the measurements should be seven inches for the lower connector, eight inches for each side, and nine inches across the top. A two-inch bandage is now placed around the patient's head, taping the ends with adhesive. This bandage must be well down on the forehead and low in the occipital region. Remove the bandage and apply small pieces of adhesive tape to hold the layers of the bandage together. This is important, for the bandage must be securely made so that it may be placed in position and removed safely. With the bandage in position, adjust the wire frame to the back of the head, enlarging or reducing the bends. Attach the back of the frame to the bandage at the occipital region with bandage or tape. Hook lower connector in position below the chin. The appliance is now completed and in position; elastic traction may now be applied when the desired attachments have been secured on the teeth or bones. (Fig. 55.)

The traction may be varied—raised or lowered or moved laterally by the application of a single bandage to the wires and extending over the head, under the chin, or along either side of the head. (Fig. 56.)

By releasing the elastics and unhooking the lower connector, the whole appliance may be easily and quickly raised or completely removed. This is desirable frequently when eating or shaving. If properly constructed, this appliance is very comfortable and will not prohibit the recumbent position of the patient. (Fig. 57.)

## LECTURE XIII

### TRACHEOTOMY: INDICATIONS AND TECHNIQUE

**T**HIS operation was for many centuries regarded by the profession with fear, due partly to want of experience and lack of a knowledge of anatomy, partly to fear of a loss of reputation, should the patient die after the operation. It was known as "the scandal of surgery." Many of the early writers admit they followed the footsteps of the surgeons of their time in declining to perform the operation, even though it is not a difficult one to the skilled anatomist.

The operation has, however, been becoming less frequent of recent years, at any rate in this country. Three factors have contributed to this diminution. Laryngeal diphtheria, occurring before the patient has been brought under treatment, has been less common; the antitoxin treatment has lessened the incidence of this form in patients submitted to that treatment; and in cases in which surgical interference has been necessary, tracheotomy has to a considerable extent been superseded by intubation and aspiration.

The emergency tracheotomy is considered one of the most spectacular and dramatic operations in surgery. An impression never to be forgotten is the observation of a rapid and complete relief afforded by a simple and well placed incision in the trachea to the cyanotic anxious sufferer fighting for life-giving oxygen, because of an obstruction in the upper air passages.

The performance of a tracheotomy should not be limited to the surgeon. Every practitioner of medicine, every dentist, should be equipped to perform this life-saving measure at a moment's notice, and under the most varied conditions, from the well-staffed and modernly-equipped operating room to the kitchen table in the country home, bady lighted, with little or no assistance.

It is interesting to note that the life of George Washington, who died following a forty-eight hour illness of an acute laryngeal condition, might have been saved had a tracheotomy been performed.

The purpose of a tracheotomy is to prevent asphyxia, by making an opening in the trachea to insure breathing below an obstruction in the trachea or larynx, and as a preliminary to other operations, such as excision of the tongue and larynx, and fracture of the trachea.

Indications for this operation, including emergencies, are many, the most important being the following: diphtheria, edema of glottis and trachea, acute infection of the floor of the mouth and neck, irremovable foreign bodies lodged in the trachea, intrinsic and extrinsic tumors of the larynx and trachea, tuberculosis, syphilis, attempted suicide and wounds of the neck, swallowing of caustic solutions, laryngeal fractures, and also in cases where intubation fails.

In many instances where there is partial interference with breathing, as in cancer, tuberculosis, abscess of larynx, pharynx, floor of the mouth and neck, the natural tendency is to procrastinate. But in such conditions as an irremovable inhaled foreign body, acute edema of the larynx and trachea, certain wounds and trauma of the larynx, an immediate tracheotomy is indicated.

The question as to when to perform a tracheotomy often arises and taxes

the judgment of the doctor, general practitioner of medicine or dentistry. One, therefore, is guided by several factors, such as the symptoms, the cause of the obstruction, and the location of the patient. However, one has a tendency all too frequently to be on the conservative side. Jackson states, "We always preach early tracheotomy, but practically always do it too late, dangerously late. . . . The patient has everything to lose and nothing to gain by waiting." Thompson goes as far as to say that more patients die from neglect to perform a tracheotomy in good time, than from operative accidents.

The symptoms and signs of obstructive laryngeal dyspnea which call for a tracheotomy are restlessness, anxious facies, ashy cyanosis, rapid shallow breathing, and indrawing of the soft tissues of the suprasternal notch, supraclavicular fossae, intercostal spaces and epigastrium. In very young children, indrawing of the sternum may be present. In such cases not a moment should be lost in giving the patient relief, as death may rapidly take place.

Jackson and Coates lay great stress on the indrawing at the suprasternal notch as the most important diagnostic sign of obstructive laryngeal dyspnea. This sign is not present in other types of dyspnea. They assert, "Failure to recognize the true meaning of this indrawing has resulted in the death of thousands for the want of a tracheotomy."

In the average case there is, therefore, no hard and fast rule as to when to perform a tracheotomy. Obviously, if the operation has to be performed, it is to the advantage of the patient to perform it early, rather than an emergency operation. The surgeon, realizing that every minute is precious and that he may be confronted at any moment with a tragedy, is forced to operate under the most trying circumstances. The result is that the vast majority of such operations are poorly performed with haste, confusion and probably poor results. If a fatality does not immediately follow, it not infrequently follows later as the result of a faulty technique.

There has been much discussion about the advantage and disadvantages of high and low tracheotomy, and the definition of what constitutes high and what constitutes low seems to vary. Some speak of high tracheotomy as an operation through the cricothyroid membrane, others designate operation above the thyroid isthmus as high tracheotomy, while still others define it as an operation through the first two tracheal rings. In recent years, there has been a gradual inclination on the part of most surgeons toward the low tracheotomy, until today when it is used exclusively. Jackson states that high tracheotomy, even for dire emergency, should not be taught. He has described a method for use in such cases, which consists essentially in cutting down on the trachea without regard to hemorrhage and with the finger in a pool of blood incising the trachea, introducing the tracheotomy tube, and then arresting the hemorrhage.

One may be called upon to perform the operation on the bed or on the floor with a pen knife, or whatever sharp instrument happens to be at hand, and without regard to asepsis. Usually one has sufficient time to do the operation under proper surgical conditions.

Morphine and other opium derivatives are contraindicated preliminary to operation because of their depressing effects on the respiratory center. It is

unanimously maintained by authorities that general anesthesia in these cases is distinctly contraindicated. Such a patient depends upon his accessory muscles of respiration for his breathing, and the anesthesia eliminates the action of these muscles, with resultant paralysis of his respiratory center from over-stimulation. Also the cough reflex is abolished, with the danger of aspirating blood and mucus.

Some authorities use a vertical incision and technique is as follows: Remember the important landmarks of the neck. (Fig. 58.) The thyroid cartilage or Adams apple is easy to locate; the cricoid cartilage is immediately below and connected with the cricothyroid membrane, and this latter cartilage is the only complete ring in the lower air passages, and should never be cut, as stenosis will result. The trachea extends downward in the midline to the suprasternal

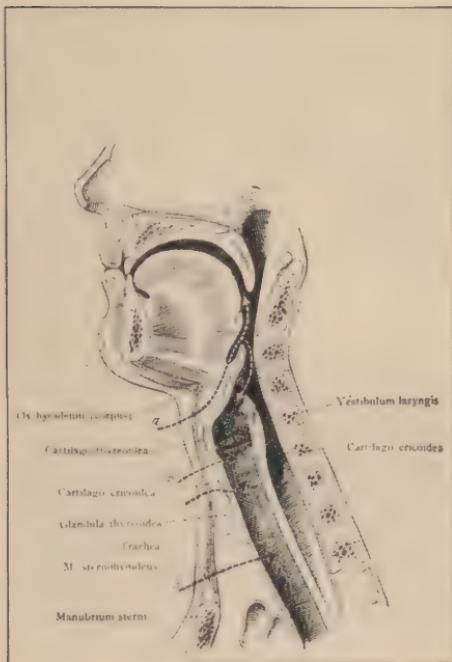


Figure 58.



Figure 59.

notch in the neck, and the important blood vessels and nerves are on each side of the trachea.

The thyroid and cricoid cartilages are located, and an incision is made through the skin two or two and one-half inches long in the midline downward immediately below the cricoid. (Fig. 59.) Divide the fascia vertically, locate the cricoid, and expose the trachea by dissection. (Fig. 60.) Retract the ribbon muscles laterally, cut through the deep fascia exposing the isthmus of the thyroid and the trachea. (Fig. 61.) Retract the thyroid isthmus upward, or, if in the way, clamp and tie at the same time. Insert a hook into one of the upper tracheal rings so as to steady the trachea. Incise in a vertical direction

in the midline of the third, fourth and fifth tracheal rings. Control all bleeding points and insert the tracheotomy tube. (Fig. 62.) After the tube is held in position, insert one or two deep and skin sutures as may be deemed necessary. (Fig. 63.)

The operation which has been very satisfactory is carried out as follows: Under favorable conditions, after preliminary infiltration of the operative field with 1 to 2 percent novocain solution to which a few drops of adrenalin have been added, a horizontal incision is made through the skin and superficial fascia just above the sternal notch. Bleeding vessels are caught with hemostats. Blunt dissection is now carried out by separating the scissors pressed on the tissues in the midline until the trachea is reached, a wide exposure of which is not practiced in order not to open up spaces for infection.



Figure 60.



Figure 61.

The inferior thyroid veins and thyroid artery may be encountered in this dissection, and if they lie so that they may be eroded by contact with the tracheotomy tube, they may be ligated. The thyroid isthmus may rarely be so developed or so low as to require division and ligation. At this stage slight extension of the neck is advantageous. A few drops of 5 percent cocaine solution are injected into the tracheal lumen, and while waiting for the cough to subside, bleeding vessels are ligated, and skin sutures of silk are placed but not tied. The trachea is now pulled upward with a hook and a vertical incision is made from below upward and as low as is practicable in the midline of the trachea. A tracheotomy tube which is neither so large as to cause

erosion of the trachea, nor so small as to render the expulsion of secretions difficult, is introduced into the trachea. A number 6 tube is usually the most satisfactory for adults. It is passed through a sheet of rubber dam which is to protect the wound from secretions. A tracheal dilator facilitates the introduction of the tube. The skin sutures are now tied, and small gauze dressings are placed over the wound. The strings, which have been previously attached to the tracheotomy tube, are tied snugly, but not tightly, about the neck, and the rubber dam secured with adhesive. Before leaving the table a rubber catheter attached to a suction machine is run into the trachea, and secretions and blood aspirated. The horizontal wound closes much more readily than a vertical one, healing usually occurring by primary union.

The after care of the patient is very important in order to prevent pul-



Figure 62.



Figure 63.

monary complications. A special nurse or trained attendant should be present constantly for the first few days. The inner tube should be removed, cleansed thoroughly, sterilized, and replaced every two hours, at first, or oftener if necessary, for secretions are expelled more easily over the smooth surface of a clean tube than over a sticky coating of partially dried secretions. The outer tube should not be changed, ordinarily, before five to seven days; it is then changed daily. In the cases in which there is a tendency to the formation of fibrinous or hemorrhagic plugs, the instillation of an ordinary medicine dropper of mineral oil occasionally helps to prevent their formation, and makes the expulsion more easily accomplished. Frequent and prolonged use of this

agent is not advised, for it is not absorbed by the tissues and may accumulate in the lungs. At first the head and shoulders are elevated, unless the patient is in shock, in order to lessen the danger of hemorrhage and to aid the expulsion of secretions.

When a patient ceases to breathe is a trying time for the dental surgeon and his staff. It is then that his temperament and training stand the acid test.

"Slitting the throat" has been fixed in the mind as being synonymous with death. The fact that this operation is life saving where indicated is not recognized by the unthinking. This vertical incision will not invade any vital structures, it is the horizontal "slitting of the throat" that severs one of the carotids or jugular veins that kills.

The Battle of Britain has brought about the invention of a gas mask for tracheotomized patients. A wife wanting to know what protection her husband would have against gas attack led to this discovery. It consists of an ordinary civilian gas mask with a long rubber tube fixed about the filters. The lower end of this tube has a metal connection which slips easily but firmly into a rubber tracheotomy tube. Exhaled air cannot be expelled in the ordinary way along the cheeks in the tracheotomized patient, so an extra exhaling valve is provided on the face-piece of the mask. The rubber tracheotomy tube fits the patient firmly with no leakage of air around the sides, but the patient is advised to encircle this with a moist handkerchief or strip of gauze.

It was found that in spite of the resistance of the long tube and the filters the patient could wear the appliance for ten minutes and more without distress or discomfort.

In a tracheotomised patient who does not wear a tube, a rubber tracheotomy tube could be fitted so that the same mask could be used.

#### SUMMARY AND CONCLUSIONS

1. Tracheotomy is a life-saving measure, and one should be equipped to perform the operation at a moment's notice and under the most varied conditions.
2. Do not procrastinate. Perform tracheotomy early when indicated.
3. General anesthesia is contraindicated. Infiltrate with 1 to 2 percent novocain.
4. Do not give sedatives, especially morphine.
5. In performing a tracheotomy, remember the landmarks of the neck, and keep in the midline and with the head well extended. The low operation is preferable.
6. Avoid, if possible, stabbing of cricothyroid membrane or cartilage.
7. In the emergency tracheotomy, every moment is of value. The patient's desperate condition often may not permit even the sterilization of instruments.
8. After care, which is often neglected, is extremely important.

## LECTURE XIV

### TRISMUS AND ITS TREATMENT

**A**CCORDING to the dictionary the term, trismus, is derived from the Greek word, to gnash. However, this is more or less misleading as there seem to be varying opinions as to the specific type of limitation of jaw movement it will include. By some it has been defined as the contraction or spasm of the muscles of mastications resulting from inflammation or irritation of the nerves supplying these muscles. While others define it as, all cases when there is limitation of motion that is not caused by bone changes within the temporomandibular joint.

In the majority of cases trismus is associated with inflammation, pain and swelling, but these factors may be absent. There may also be a variation in the severity of the condition as in some cases the jaws are fixed rigidly in occlusion while others may accomplish a slight opening but not a normal one. Any effort to depress the mandible may or may not be painful.

Acute inflammatory conditions that involve the floor of the mouth, cheeks, pharynx, parotid gland, external auditory canal, and periosteum of the external surface of the mandible in the region of the insertion of the masseter muscle may bring about the onset of trismus, these being the most common structures affected by pathological conditions that produce the causative factors. The muscles most frequently and usually affected are the masseter and internal pterygoid, although the entire group may be involved in this condition.

Trismus is more frequently due to a dental reflex. However there are other causes; consequently, it is not always a simple matter to locate the primary cause, partially because of the inability to gain access to the oral cavity. It is therefore essential that a complete x-ray examination be made in all cases to aid in location of the lesion. The oral tissues should be carefully examined and palpated as much as is possible.

The following may be classified as the most common and important causes:

1. Dental reflexes such as impacted or erupting mandibular third molars, abscessed teeth or acute inflammation in and about the teeth.
2. Lesions of the jaws—as necrosis from chronic infection brought about by tuberculosis or actinomycosis.

Osteomyelitis—due to infection such as may be the result of extractions or fractures.

Periostitis—due to syphilis, typhoid or other infections, or to trauma.

Fractures—especially those occurring in and around the angle of the mandible. Frequently there is limitation of motion after wiring has been removed.

Tumors—such as periosteal sarcoma or other malignant growths invading the muscles of the mandible and giving rise to a certain amount of irritation.

3. Lesions of the muscle—such as myositis or inflammation of the muscle tissue due to inflammatory rheumatism.

Gunshot wounds of the mandible in which the muscles of mastication are involved and have consequently been traumatized.

Trauma to the muscles brought about by extractions and faulty technique

in administering anesthesia, where the solution has been injected directly into a muscle or when micro-organisms have been carried into the tissue by means of the needle.

Trichinosis—in which the trichina spiralis penetrates the muscle fibers and sets up an inflammatory swelling, tenderness and edema. In very acute cases there may be a marked degree of trismus. The toxin of the parasite causes a marked increase in the number of eosinophilic leukocytes, this being an important diagnostic point.

4. Lesions of the oral cavity—such as an abscess in the floor of the mouth, acute gingivitis, stomatitis, ulcers of the tongue or inside of cheek, peritonsilar abscess or an abscess beneath the pterygoid muscle resulting from extraction. In highly neurotic individuals, especially a child, a severe throat infection may be associated with trismus.

5. Lesions of tempromandibular joint—such as arthritis, or inflammation of the joint due to an infection as gonococcus infection or general infection.

Synovitis and other irritating conditions due to trauma and recurrent dislocations of the mandible may cause mild trismus.

6. Lesions within the skull—such as meningitis of any variety, tuberculosis or septicemia. By irritation of the cranial nerves, especially the motor division of the trigeminal nerve.

Brain tumors, especially those in relation to the gasserian ganglion or trigeminal nerve. Pressure may be exerted here by marked increase of general intracranial pressure.

7. Tetanus—In this condition the toxins from the tetanus bacillus have affected the central nervous system and for some unknown reason the muscles of mastication are the first to be affected, thereby completely fixing the jaws. If there is involvement of the muscles of the neck and tongue, and the facial muscles tend to become involved in tonic contraction, giving a rather characteristic expression, tetanus should be suspected.

8. Hysteria—Inability to open the mouth may be a hysterical phenomenon which is most common in young women. The patient is usually of a nervous temperament, and in most cases gives a history of having had similar attacks before, usually recovering rather suddenly. The attacks are, as a rule, associated with some mental strain or worry, and while the attack lasts, which may be for weeks, the amount of opening varies. The treatment consists of encouragement and assurance that the condition will disappear. A hasty diagnosis of hysteria should not be made, for such cases are frequently found to be due to some physical lesion.

Regardless of the causes and the severity of trismus the prognosis is generally good.

After a careful examination and the primary cause or causes have been determined, the removal of the cause is the first step taken in the treatment of trismus. In cases where the mouth cannot be opened wide enough for an oral examination or treatment, some type of mechanical apparatus may be used for this purpose. However, this should not be attempted unless absolutely necessary and then only with the greatest care. If the mouth is forced open when

acute symptoms are present the limitation of motion becomes more severe as a result of further muscle damage.

In cases where there is cellulitis and a localized area on the face or in the submaxillary region, it is not necessary to open the mouth at all for the present. An incision is made and drainage established extraorally. Shortly after this is accomplished the patient will be able to open wide enough for a more complete intraoral examination and further treatment of the primary cause.

In cases where trismus is caused by erupting mandibular third molars the



Figure 64.

mouth can in the majority of cases be opened to a certain degree; that is, enough to make an examination and administer treatment. This examination will usually reveal a swollen and irritated area around the tooth in question. There may or may not be pus present; if there is, drainage must be established. In all these cases irrigation of the area between the tooth and gum is necessary, plus the application of a suitable medicinal agent to the overlying

flap which is usually present. The medicinal agent should be worked well down into the space between the tooth and gum. Should there be any glandular involvement, hot moist applications can be applied externally. As the acuteness of this area diminishes so will the amount of trismus until it is possible to either remove the flap or the tooth, whichever is necessary.

The treatment of all cases of trismus is not so simple, as there are cases where mechanical means must be resorted to. It may be well to mention at this point that the mechanical treatment of trismus should not be attempted until the causative factor has been removed. Then by the careful use of mechanical force the jaw can be exercised daily and the limitation of motion will soon be overcome. The cases will differ in the amount of treatment required as some will take longer than others.



Figure 65.

The dangers resulting from forcing the jaws open too rapidly must also be taken into consideration. Rapid separation is a dangerous procedure and may result in the fracture of the mandible, fracture of the teeth, alveolar dental periodontitis or tearing of the inflamed muscles.

There are various mechanical devices recommended for separating the jaws and others for exercising the muscles after space between the teeth has been opened far enough for their introduction. It should be borne in mind that if clothes pins, paper clips or jack screws are used in forcing an opening in the anterior part of the mouth too much pressure may result in tooth or tissue injury. The anterior teeth cannot withstand a great deal of pressure. In

cases where there is a labial version of the anterior teeth too much pressure will tend to force them farther forward and not separate the jaws. On the other hand, if the patient has an underbite or an overbite the appliance will tend to act as a crowbar and displace the teeth to such an extent that there is a possibility they will be lost; when possible, pressure should be brought to bear on the cuspids or teeth posterior to them.

Doctor Dorrance of the University of Pennsylvania uses jaw separating forceps if there isn't enough space for the introduction of the so-called Dorrance-Webster jaw exerciser. These forceps have fairly broad flat tapering jaws and are inserted posterior to the cuspids. When the space is sufficient the exerciser is then introduced. This instrument is composed of two flat plates conforming with the arches and protected with heavy soft sheets of lead and

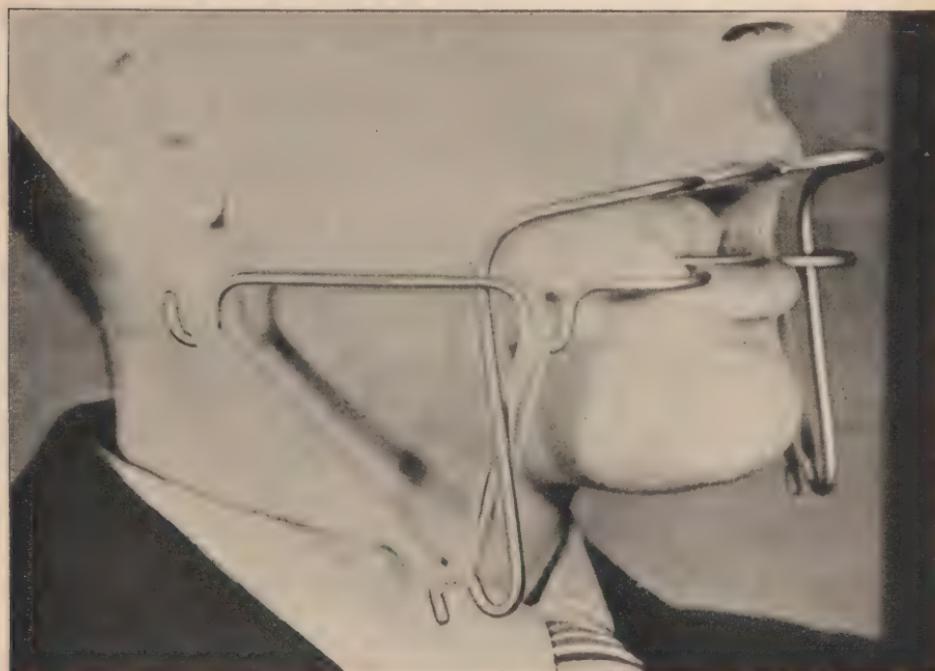


Figure 66.

are connected on each side with a spring which extends out to approximately six inches. These springs are in turn connected to each other with two rods running transversely to stabilize the appliance and prevent play. To strengthen these springs an additional spiral spring is applied on each side and this is of such form that it can be regulated by a nut to change the strength of the main spring to supply the desired force to be exerted upon the flat plates.

The flat plates of the exerciser are introduced in opposition to each other between the maxillary and mandibular planes, while the spring of the instrument is controlled by the grasp of the patient, who applies his hands on each side. The patient then gradually relaxes the grasp, thereby releasing as much

pressure as he can stand. This enables him to gradually release the force until the full pressure is exerted.

Due to the construction of this appliance, the patient can open and close the mouth while it is in place. It is recommended that the patient use the exerciser ten minutes out of each hour.

Blair and Ivy describe an apparatus that presents many advantages. It can be made as a stock appliance, in three sizes, ready for use when there is an initial opening of but one centimeter between the teeth. It is stable, easily fitted and easily made. (Figs. 64, 65, 66.) There are two flat metal trays that pass between the occlusal surfaces of the upper and lower teeth. To the outer surfaces of these are soldered heavy wires which pass out of the mouth and curve backward over the cheeks in the manner of a Kingsly splint. The wire attached to the upper tray on each side turns down at a right angle and ends in a hook about three inches lower down. The wire attached to the lower tray passes directly backward horizontally and is provided with a hook at a point opposite the downward turn of the upper wire. The dilating force is a heavy elastic band placed between the hooks on each side. The elastics produce a constant counteraction to the elevator muscles of the mandible, which at the same time are permitted to function, the upper and lower arches being at no time fixed. Where additional stability is desired, softened modeling compound may be placed in the trays before they are inserted. The dilating force can be regulated by the size of the elastic bands. Where forward movement of the condyle is advisable, a second rubber band can be placed between the hook on the wire attached to the upper tray and one placed at the extreme posterior end of the lower wire. This apparatus can be removed at meal time, or whenever desired, and replaced by the patient.

Under this treatment the case should show from two to four mm. improvement per day and a permanent opening of thirty mm. between the anterior teeth in about thirty days.

In conclusion, it may well be said that too much care cannot be given in the diagnosis and treatment of trismus, and by all means it should not be confused or mistaken for true ankylosis. Owing to the numerous pathological conditions being directly responsible, the case may present quite a problem as to the exact location of the primary cause. Cases have been reported in which the cause of an intense trismus could not be found after months of exhaustive search.

There are also other mechanical appliances used in its treatment; however, the principle is the same in all. The ones heretofore described are the most simple and the most common. Their greatest advantages are that they are ready for immediate use in any case where the separation between the teeth is very slight, without the necessity of impression taking.

## LECTURE XV

### DIETARY MANAGEMENT IN THE TREATMENT OF MAXILLO-FACIAL CASES

MANY articles have been published on the subject of maxillo-facial cases, but most of them deal only with the operative procedures, thus leaving the erroneous impression that the duties of the dentist are finished as soon as the patient leaves the operating room. One of the most important factors involved in the treatment of this type of case is the postoperative plan of treatment, including attention to the patient's diet.

It is true that prompt treatment of wounds or reduction of fractures and the retention of the parts in proper relation are of prime importance, but this is only a part of the treatment necessary to bring the case to a successful termination.

Dietary management of these cases presents a more difficult problem than similar injuries or operations in other parts of the body. This is due to the intimate connection of the mouth with body metabolism. When a patient is temporarily deprived of his power of mastication, rendering the proper mastication of food impossible, the digestion and assimilation of the food will be greatly interfered with unless proper measures are taken in the preparation of the food and the feeding of the patient.

The fact is frequently overlooked that proper nutrition for these cases is vitally important if the normal healing processes are to take place. Nothing is more discouraging to a patient's morale than to be continually hungry or to be forced to subsist on the same tasteless liquid diet for a period of weeks or months. This abrupt change in the nature of the diet is almost certain to impede cell nutrition and influence the metabolism of the reparative bone processes.

Cases may vary from some rather simple injury of the oral cavity to those with compound comminuted fractures of the jaws and great loss of substance. This is frequently encountered in war wounds of the face. In the case of the uninjured fracture of the jaw, the method of immobilization is usually by intramaxillary wiring with intermaxillary elastic traction, or some type of splint. In this type of case we usually have the full cooperation of the patient, thus simplifying the feeding. But in other cases where there is loss of continuity of the lips, cheeks, palate, tongue, or floor of the mouth as is frequently found in gunshot or shrapnel wounds, special methods of feeding must be devised.

Much has been written about foods and food elements, so it is not the purpose of this paper to go into great detail, other than to state a few fundamental facts that are necessary to know if intelligent dietary planning is to be attempted.

A food is any substance than can be utilized in a living organism for functional or structural purposes. A complete food must contain all the elements necessary to construct and maintain the activities of the body tissues. Such a food must contain water, mineral matter, nitrogenous matter, carbohydrates,

fats and vitamins. It follows that a properly balanced diet is essential to keep the patient in comfort and to maintain his normal weight. It has been found that patients with a simple fracture of the jaw tend to lose weight at first, but with proper dietary management will regain their normal weight within two weeks and are frequently heavier upon termination of treatment than upon admission.

A normal diet contains approximately four times as much carbohydrate material than fats or proteins. The carbohydrates will be varied according to the activity of the patient, and also to comply with his ability to digest this food. In general the diet for these maxillo-facial cases should be rather high in carbohydrate content and relatively low in fats and proteins. Foods tending to cause constipation must be avoided. The diet should have a high nutritional value and contain an adequate amount of calories. Each case must be treated individually as the natural body requirements will vary rather widely. An adequate number of calories may be as little as 1500 daily for a bed patient, to as much as 3500 or more daily for an active or convalescent patient.

There are three groups of calorie producing food elements; namely, carbohydrates, proteins, and fats.

1. **CARBOHYDRATES**—These are the sources of energy and heat and are found in starches and sugars.

2. **PROTEINS**—These are the nitrogen containing foods and supply the material necessary for the repair and maintenance of body tissues. Eggs, milk, meat, fish and cheese are important sources of this element.

3. **FATS**—Fats are also converted into energy and the presence of this element is in some way necessary for the metabolism of carbohydrates. Sources are butter, lard, nuts, etc.

We now come to the subject of vitamins and although much work has been done in this field within the last few years, our knowledge of them is still far from complete. The term "vitamin" designates a group of substances which have a regulating action on the utilization of foodstuffs. They must be supplied as such as cannot be manufactured by the human cells. They are essential for the continuance of normal health and are of even more importance in the case of a wound or infection.

1. **VITAMIN A**.—It has been found that a deficiency of vitamin A may play an important part in the causation of postoperative complications, and brings about a general weakening of the body and its ability to resist infection. Evidence is still lacking to prove whether the increased susceptibility to infection is due to the weakening of the tissues and the breakdown of local defense, or whether the vitamin actually has an anti-infective function. The chief sources of vitamin A are milk and other dairy products, eggs, liver, cod liver oil, spinach, lettuce, carrot and oranges. Its precursor, Carotene, from which the body can actually synthesize vitamin A, is widely distributed in the plant world.

2. **THE VITAMIN B COMPLEX**. This group of vitamins, formerly thought to be a single vitamin and designated as vitamin B, has received much attention in recent literature. Nicotinic acid deficiency often manifests itself as a stomatitis

closely resembling Vincent's stomatitis but which clears up upon an adequate intake of this factor. Recently, deficiency of riboflavin with oral manifestations was reported. Thiamin, Vitamin B<sub>6</sub>, and other B complex factors are essential for health. Sources of the vitamin B complexes are whole cereals, milk, brewers and fresh yeast, and nearly all vegetables.

3. VITAMINS C AND D. In fracture cases the essential thing is the formation of new bone. It is in this process that vitamins C and D are of the most importance and for this reason they are to be discussed together. The repair of bone may be likened to the building of a structure in which the calcium and phosphorus represent the building stones and the vitamin elements the cementing substance. The process of bone formation in healing may be sketched briefly as follows: Osteoblasts collect in the area under repair and exude a viscid gelatinous fluid which normally congeals to form a dense calcified mass. Osteoblasts exude the fluid even though the diet is inadequate, but it does not congeal to form collagen unless vitamin C is present in adequate amounts. Calcification of the collagen requires vitamin D and, of course, calcium and phosphorus. But calcification is only one step in the process, and no matter how adequate the amount of vitamin D and lime salts may be, unless this liquid collagen congeals we do not have a satisfactory bone repair. This cannot occur without vitamin C. The chief sources of this element are fresh fruits and vegetables; oranges, lemons, and tomatoes being excellent sources.

Vitamin D has the property of promoting the assimilation of calcium and phosphorus and so is essential to the formation and development of bone. Vitamin D has also been shown to be essential to the general development of the body. The chief sources are liver, egg yolk, and some being present in milk. Irradiated ergosterol may be used to bring about the formation of vitamin D.

In addition to the food elements just mentioned, studies have shown the importance of mineral elements in the diet such as sodium, potassium, calcium, magnesium, chlorine, iodine, phosphorus, sulfur, iron, manganese, copper, zinc, and cobalt.

It can be readily seen that a diet containing all of these essential food elements, prepared in a manner so that it can be readily consumed and assimilated by maxillo-facial patients, requires much study and thought. The need of maintaining appetite appeal is of great importance. One is very likely to tire of food if it is not appetizing or if the same diet is given over a long period of time. Therefore, an attempt must be made to have a diversified as well as a balanced diet. The food should be well cooked and properly seasoned and should be served hot and not lukewarm.

In order to simplify some of these problems, it has been found practical to have two types of diets in addition to the regular diet. They are, namely, the liquid diet and the soft diet. In the larger hospitals where a dietician is on duty, the preparation of these diets is greatly simplified. These dietetic specialists are very willing to prepare and serve diets as recommended by the dental surgeon, and are grateful for suggestions, since information regarding the feeding of these cases is rather meager. Where dieticians are not available, the dental surgeon must take an active part in the preparation of these

diets. Mess sergeants and cooks cannot be expected to know how to cope with these special situations. This can only be done by instructing the enlisted personnel concerned, in the rudiments of this type of dietary management.

As a preliminary step in charting the actual menu, a rough grouping of the following seven subdivisions showing the types of food available for use, is made. This diet list is intended to serve as a basis from which daily menus may be prepared for cases requiring a special diet. This will include all fractures of the jaws that are immobilized by wiring, severe trismus, cases involving great tissue damage or loss of substance and other cases of similar character.

1. BEVERAGES.—Coffee, tea, milk, buttermilk, eggnog, malted milk, lemonade, and orangeade.

2. CEREALS.—They should be either finely processed infant preparations or freshly prepared cooked whole grains, carefully strained. When thinned with milk or cream they offer a valuable means of regulating calories by the combined use of the milk, milk and cream, or all cream.

3. DAIRY PRODUCTS.—These are so essential in dietary planning that about one-half of the desired nutrient value of the diet may be supplied by the combination of milk and cream.

4. DESSERTS.—These have two rather useful qualities as they provide a good method of serving milk and eggs and are usually appealing to the appetite. They may include soft custards, junkets, jello, and thin cornstarch pudding.

5. FRUITS.—These include puree of apple, peaches, pears, apricots, prunes, etc.

6. SOUPS AND BROTHS.—These include, cream soups, vegetable soups, chowders, beef or chicken broth, oyster stew and beef juice. The food value may be enhanced by the addition of a fine cereal or pureed vegetables.

7. VEGETABLES.—These include pureed tomatoes, squash, carrots, beets, cauliflower, lima beans, asparagus, turnip, celery, spinach, peas and mashed potatoes. The nutrient value of vegetables is so well known that it need not be repeated, but their valuable mineral content, especially calcium and phosphorus should be noted.

In addition to the types of food available, it is necessary to know the caloric values of the elements which comprise them. The following table shows the approximate number of calories placed opposite each type of food, that would maintain a satisfactory balance in a daily diet. Space prohibits a complete list of foods with their caloric content, but this information may be obtained in numerous texts on dietetics. Mead's "Oral Surgery," from which some of this material was obtained, contains an excellent chart.

Cereal, two servings	125 calories
Cream	480 calories
Eggs, two	150 calories
Fruits, pulp and juice	500 calories
Milk, one quart	670 calories
Sugar	150 calories
Vegetable, pureed, two servings	50 calories

At the end of this article will be found two sample daily diets, one for the liquid diet and one for the soft diet.

#### METHODS OF FEEDING

Diets for patients with no loss of continuity of the lips or cheeks, usually need not be prepared in such an extreme liquid form. Even though the teeth are fixed in occlusion, there is usually sufficient space between the teeth or in back of the most posterior teeth to allow for the normal intake of food. The extraction of a tooth for the sole purpose of facilitating feeding should never be done. The only problem presented here is the inability of the patient to masticate food after entrance to the mouth.

There are various methods of feeding that can be used, depending upon the type of case under consideration. Scogin has outlined a method of nourishment for the various types of maxillo facial cases, especially for those patients with fractures. The outline is as follows :

1. DRINKING TUBE METHOD (FOR LIQUID DIETS).—This method can be used where there is continuity of the lips, cheeks, soft palate, tongue and floor of the mouth. However, one or more anterior teeth must be missing in order to allow for the entrance of a glass tube into the mouth, so that the tongue can be placed against the end of the tube.

2. CUP AND BOWL FEEDING (FOR LIQUID AND SOFT DIETS).—This is a very useful method of feeding patients with mandibular or maxillary fractures retained by intermaxillary wiring. Patients with trismus or bone grafts may also be nourished in this manner. Kingsley arms and rhinoplastic scaffolding should always be indented into the upper lip, a few millimeters from the corner of the mouth so that the patient will not drool while executing sucking movements. Mead brings out the fact that patients can often take food from a small pitcher or teapot by placing the spout between the lips.

3. SPOON FEEDING (FOR LIQUID AND SOFT DIETS).—This is the method of choice in cases where there is loss of continuity of the buccal orifice, making it impossible to use other methods. It may be used when the patient does not have the use of his arms.

4. OROPHARYNGEAL FEEDING (FOR LIQUID DIET).—This is a valuable method of feeding in cases where there is extensive loss of destruction of the tissues of the lips, cheeks, palate, tongue or floor of the mouth. The food is deposited by means of a large sized catheter onto the dorsum of the posterior aspect of the tongue, a swallow at a time.

5. NASOPHARYNGEAL FEEDING (FOR LIQUID DIET).—This is a valuable method of feeding serious cases with extensive tissue loss, especially in the floor of the mouth. A lubricated catheter of suitable size is passed through the nostril and inserted until the tip of the tube is below the uvula and into the oropharynx. The patient can control the amount of food by pressure on the rubber tubing or by signal.

6. RECTAL FEEDING (FOR LIQUID DIET).—This method is resorted to only in very serious cases where the patient is unable to swallow.

Following are two sample daily diets :

## LIQUID DIET

6 A. M.			
Grapefruit juice	1 glass	80	calories
Cream of Wheat gruel	1 cup	85	calories
Cream	½ cup	95	calories
Tea with cream	1 tbsp.	49	calories
9 A. M.			
Eggnog	1 glass	262	calories
12 Noon			
Cream of pea soup	1 cup	140	calories
Baked custard with sugar	1 cup	220	calories
Cocoa	1 cup	135	calories
3 P. M.			
Orange juice	1 glass	50	calories
6 P. M.			
Chicken broth with rice	1 cup	115	calories
Ice cream	½ cup	222	calories
9 P. M.			
Chocolate milk shake	1 glass	260	calories
	Total daily calories	1,713	calories

## SOFT DIET

6 A. M.			
Orange juice	1 glass	50	calories
Oatmeal	½ cup	61	calories
Cream	½ cup	120	calories
Sugar	2 tsp.	40	calories
Egg	1	75	calories
Coffee, cream, sugar	1 cup	75	calories
9 A. M.			
Milk and cream	1 glass	300	calories
12 Noon			
Cream of celery soup	1 cup	140	calories
Apple sauce	3 tbsp.	201	calories
Malted milk	1 glass	221	calories
3 P. M.			
Eggnog with cream	1 glass	262	calories
6 P. M.			
Chicken broth	1 cup	30	calories
Puree of spinach	½ cup	12	calories
Jello	1 serving	80	calories
Tea, cream, sugar	1 cup	140	calories
9 P. M.			
Buttermilk	1 glass	75	calories
Cream (added)	½ cup	120	calories
	Total daily calories	2,002	calories

## LECTURE XVI

### THE CONSTRUCTION OF A SECTIONAL SPLINT

SPLINTS applied to the teeth are useful in maintaining fractured segments of the mandible and maxillae in their proper relation during the healing process. They are also useful for anchorage in the gradual reduction of fractures, and as a base for the attachment of intra-oral arms, extra-oral arms and rhino-plastic scaffolding.

The first requirement in the construction of a successful splint is a good, accurate impression of the teeth and adjacent tissues of both the maxilla and mandible. One of the hydro-colloid compounds is the material of choice for this purpose, although plaster of Paris may be used. The model should be poured in stone, and the original should be immediately duplicated. The actual construction and fitting of the splint is done on one or more duplicate models, the original never being used for this purpose. There are two reasons for this: first, the original or master model will serve as a case record, and sec-



Figure 67.



Figure 68.

ond, it will be available for a new start in case an accident occurs during the splint construction, and will eliminate the possibility of having to retake the impression.

A large percentage of fracture cases are presented with considerable displacement of the fragments. The impression is taken of the parts as they are, and it of course becomes necessary to cut the cast and reassemble it with the teeth in the proper relation to the opposing teeth. It should always be the duplicate model that is cut and reassembled, never the original. This reassembled model is now duplicated and it is on this second duplicated model that the actual construction of the splint takes place. This working model as it may be called, will, of course, be destroyed during the casting or vulcanizing of the appliance, but the reassembled cast from which the working model was made will still be available for fitting and finishing the splint.

There are a great many possible variations of the sectional splint, but they

depend on the principles of the simple, basic, three-section splint about to be described. The material used may be silver, vulcanite, or acrylic resin, preferably of the clear type. Each material has advantages and disadvantages and the operator must decide which to use in the individual case. The clear acrylics have a number of decided advantages. They are easily made and are inconspicuous when in place in the mouth. Being transparent, the condition of the teeth and underlying tissues can be seen without removing the splint. The clear acrylics are radiolucent, and as they cast no shadow, it is possible to take x-rays with the splint in position. This is not true of silver or vulcanite. Both of these materials are decidedly radiopaque and cast heavy shadows often obliterating parts of the x-ray with which we are greatly concerned. When silver is used the splint can be made stronger with much less bulk. However, the harder process of casting, and the greater difficulty of fitting and finishing must be listed as disadvantages when compared to the other two materials. Regardless of which material is used, the principles of construction are exactly the same.



Figure 69.



Figure 70.

The basic sectional splint consists essentially of one lingual segment and two buccal sections. The buccal sections are in reality one segment which is split at the median line, thus making two sections. The two buccal sections are connected to the lingual segment distally to the last tooth included in the splint on either side by a piece of 14 gauge half round clasp wire. Orthodontia band material may be used in lieu of this, but clasp wire is preferable and more likely to be available. An undercut button about  $\frac{1}{4}$  inch in diameter is built into the buccal portion of the splint at the median line. The cut which divides the buccal portion into two sections is made vertically through this button. When the splint is placed in position in the mouth, a brass ligature wire is passed around the two halves of this button and when tightened pulls the buccal section firmly about the teeth and secures the appliance in the mouth. For retention and stability the splint depends on its grip on the bell portion of the crowns of the teeth. The contour of the teeth will govern the area to be

covered, but as a general rule the cervical and middle thirds of the teeth should be covered. The splint should extend over the gingiva two or three millimeters. This gingival extension has nothing to do with the retention, but serves as a protection to the gingiva and makes cleansing of the mouth and appliance easier. (See Figs. 67 and 68.)

In many cases it is necessary to use extension arms, either intra-oral or extra-oral. These are inserted into square tubes which have been built into the splint. In cases where it is desirable to have intermaxillary traction, small flat undercut buttons are built into the buccal sections of the splint at several points and the desired traction obtained by the use of elastic bands which are hooked to these buttons. (See Fig. 74.)

The first step in the actual construction of the splint is to get the properly duplicated working model. If the splint is to be constructed in either vulcanite or acrylic resin the model should be poured in stone. If silver is the material of choice, the model must be poured in investment as the splint will be cast directly to this model.



Figure 71.



Figure 72.

The clasp wire which forms the hinges between the lingual and buccal segments is now adapted. The wire is carried around the distal surface of the last tooth to be included in the splint on each side of the mouth and is kept as near the gingiva as possible without impinging on the soft tissue. It is carried around on the buccal and on the lingual surface of the tooth as far forward as the mesial surface. At this point the wire is bent at right angles and cut off about one-half inch away from the surface of the tooth on both the buccal and lingual sides. These portions of the wire which extend at right angles to the tooth are later embedded in investment when the case is flasked for packing and by this means the wire is held in place while the case is being packed, or in the case of the silver splint, while it is being cast. (See Figures 69 and 70.) The adaptation of the wire should be fairly accurate around the distal part of the tooth, but along the buccal and lingual surfaces close adaptation is not desirable. There should be space between these surfaces of the tooth and the

wire, as the wire must be embedded in the splint material. This is possible only if the necessary space is provided into which the material can flow.

The simple, basic splint has no extension arms, but if they are to be used the tubing is placed in position at this point. The proper size of tubing and wire are selected and cut to the necessary length. There are several ways of holding the tubing in place during the curing or casting processes. The tubing may be waxed into place, a wire inserted and extended a sufficient distance so that its end will be embedded in investment when the case is flasked. By this method the wire is held stationary and the tubing is like a sleeve on the wire. As the wire fits the tubing accurately there is enough frictional retention to hold the tubing in its proper position on the wire. This method works very well in many cases, but when the wire has to be extended too far, too much flexibility results and there is usually some movement from the pressure of packing and pressing the case. A better method is to follow this same procedure exactly, but in addition solder the tubing to the clasp wire hinges or connectors on the splint. If this is done, it is almost impossible to produce movement.



Figure 73.



Figure 74.

Nickel-silver square tubing and wire to fit is ordinarily used. For intra-oral extension arms, 10 x 14 gauge square tubing and 14 gauge square wire are used. Because of their greater length, extra-oral extension arms and rhinoplastic scaffolding must ordinarily be made of a more rigid material than short intra-oral arms. Additional rigidity may be obtained by using tubing and wires of a larger gauge, or by soldering two small gauge tubes parallel to each other. (See Figs. 71 and 72.)

The clasp wire hinges are put in proper position on the model and held in place with sticky wax. If tubes are used they are also waxed in position. The splint is then waxed exactly as it is to be when finished except that the buccal segment is solid. The cut at the median line which divides the buccal segment into two sections is made with a fine saw after the case is vulcanized and polished. For a vulcanite or acrylic splint one and one-half thicknesses of pink base plate wax should be used. The waxed splint consists of nothing more than

a band of wax around the buccal and lingual sides of the model which covers about two-thirds of the buccal and lingual surfaces of the teeth and extends over the gingival margins about two or three millimeters. The clasp wire on the distal surfaces of the last teeth must be kept free of wax as the spring action of the wire should be maintained. It must be remembered that these wires are simply connectors between the lingual segment and the two buccal sections of the splint. They hold the parts of the splint together in a single



Figure 75.



Figure 76.



Figure 77.



Figure 78.

piece but allow the buccal sections to be sprung outward or opened so that the splint can be readily applied or removed. (See Figs. 67, 68 and 73.)

If there are any teeth missing, the space is waxed solid, the wax being carried to within a millimeter or two of the occlusal surfaces of the teeth adjoining the space. Missing anterior teeth can be replaced with vulcanite teeth of the proper shade, size and shape. When this is to be done, the teeth are ground to fit as for any partial denture and placed in position before the wax

is applied. The case is then waxed, the pins and ridge lap of the vulcanite teeth being attached to the lingual segment of the splint. The buccal portion of the finished splint must be free to lift away from the vulcanite teeth when the splint is opened, so in order to make this possible, the labial surfaces of the replaced teeth should be covered with 0.001 inch tin-foil before the buccal portion of the splint is waxed over them. The tin-foil acts as a separator and will permit easy separation of the part of the splint in contact with the labial surfaces of the porcelain teeth.

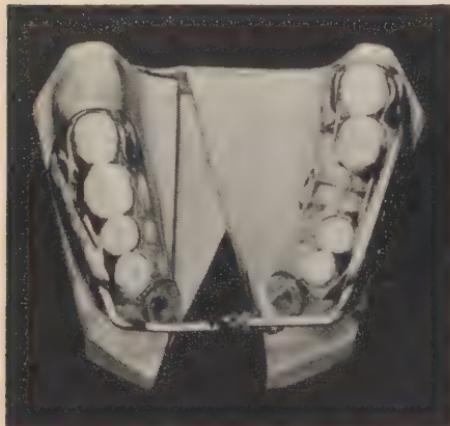


Figure 79.



Figure 80.

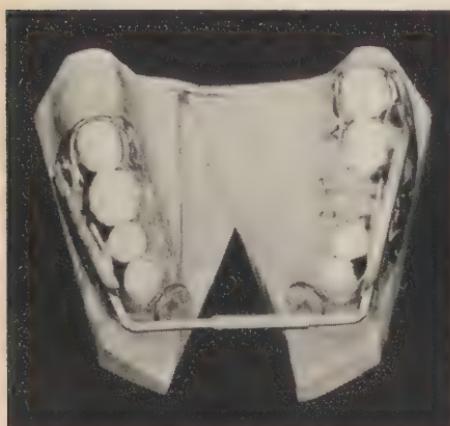


Figure 81.



Figure 82.

The edentulous spaces which have been filled in will have to be split vertically from mesial to distal to allow the splint to spring open on the hinges. These cuts are made with a fine saw after the splint is finished at the same time the median line cut is made. Application of a brass ligature wire through holes drilled in the splint in these edentulous areas will tighten the appliance

at these points and materially increase the grip of the splint on the teeth. (See Fig. 74.)

The waxing for a silver splint is exactly the same as for the vulcanite or acrylic appliance except that it is not as thick, two thicknesses of 28 gauge casting wax usually being sufficient.

When waxing is completed the crowns of the teeth on the stone model are cut off flush with the wax. The case is then flasked, boiled out, packed, vulcanized and polished, the same technique being used as for any denture. If



Figure 83.



Figure 84.



Figure 85.

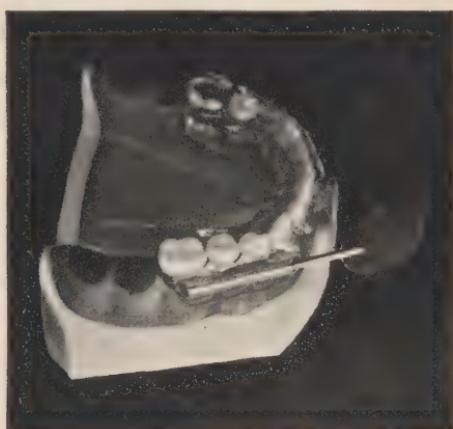


Figure 86.

acrylics are to be used, it will be necessary to tin-foil the case on both sides.

If the splint is to be cast in silver, the model upon which the waxing is done will have to be poured in investment. Sprues and air-vents are placed and the case is invested, burned out and cast as for any large one-piece casting. The metal used in these splints is pure silver to which 10 per cent pure copper is added. When the metal is cast, it flows around the clasp wire which is em-

bedded in the mould and which is to form the hinges of the splint, usually forming a very strong union with it. If, for some reason, the silver fails to completely cast around the wire, the defect can easily be remedied by applying a little gold or silver solder.

After the splint is completed, including the making of the cuts at the median line and through the edentulous areas, it is tried on the master model. Minor adjustments in the way of trimming are usually necessary and they are more easily done on the master model than in the mouth. Care should be exercised in trimming around the teeth as the splint will not have a tight grip on the teeth if too much material is trimmed away.

Figure 75 shows a splint waxed on the model, the rough casting after being removed from the investment, and the splint polished. It will be noted that the cuts through the button at the median line and through the edentulous areas have not yet been made.

As stated previously there are numerous variations of the simple sectional



Figure 87.



Figure 88.

splint. One of the most useful of these variations is the one shown in Figs. 76 and 77. This is the basic three section splint which carries an intra-oral extension arm for the control of an edentulous posterior fragment which tends to an upward displacement through muscle pull. Parallel holes have been drilled through the edentulous areas into which brass ligature wires can be run, and when tightened will increase the grip of the splint on the teeth. (See Figs. 76 and 77.)

One of the most interesting variations is the appliance shown in Figures 78, 79, and 80. In this case there has been collapse of the fragments and a splint which will produce expansion is necessary. As shown in the illustrations, the appliance consists of two separate unilateral sectional splints, each having a tube into which intra-oral extension arms are inserted. Elastic bands placed around hooks on the ends of the extension arms produce the necessary traction for expansion. (See Figs. 78, 79, and 80.)

Figure 81 shows the same type of case after expansion has been accom-

plished. A section of square tubing slips over the ends of the extension arms as a sleeve, thus maintaining the right and left fragments in the expanded position.

Figure 82, 83, and 84 show the same type of case again, but here more of a restoration has been made. The anterior segment, which maintains the expansion, consists of a square wire to which porcelain teeth are attached by an acrylic base. The ends of the square wire slip into the tubes on both unilateral splints and the section is held in position not only maintaining the expansion, but restoring lost teeth and tissue as well.

Figure 85 shows an acrylic splint for the same type of case, but it is made in a single piece without the use of tubes or arms. The cuts are made on the lingual section just mesially to the first bicuspids. The area from cuspid to cuspid is solid and continuous with the buccal segment, the porcelain teeth being attached to this portion. When open, the two lingual segments open inward, and when closed they are secured to the buccal segment by brass wires which pass through holes drilled in the splint mesially to the first bicuspids.

Figures 86 and 87 show a splint with an intra-oral extension arm to support a modeling compound stent around which a dental graft may be placed, for deepening the buccal sulcus or for lowering muscle attachments.

Figure 88 shows an interesting variation in which the splint consists of one buccal and one lingual segment and hinged on one side only. Two parallel holes are drilled through each of the edentulous areas in the first bicuspid regions, and brass wires passed through these holes and tightened produce the necessary grip of the splint on the teeth to hold it in position.

There are many possible variations, but the ones shown will illustrate the flexibility of design of the sectional splint.

















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